T-NAWDEX

(THORPEX-North Atlantic Waveguide and Downstream Impact Experiment)

workshop summary

This report summarizes the T-NAWDEX workshop held in Karlsruhe on 20 March 2013.

Key presentations were given informing about the interest in different countries for a participation in the T-NAWDEX campaign. After that a plenary discussion focused on scientific goals. A set of hypotheses were formulated and additionally a number of questions regarding the preparation were addressed.

Presentations are available at: http://www.pandowae.de/en/t-nawdex-2013/talks

At the end of this document the primary scientific issues, hypotheses and logistics are listed.

Contents

Key presentations

1) Summary on a future HIW Project (Brian Golding)

Discussion on a future follow-on-project for THORPEX (where we go to?) New focus: needs of users (small scales, short time scales), human economic impacts, communicate weather information. Science: changes during last years (resolve convective scale new, weaknesses DA and uncertainties), Linkages to Polar Prediction Project (HIW component) and Seasonal to sub seasonal project (at the long time scales: boundary 15 days).

T-NAWDEX: research at the source (how to predict the environment of hazards) fundamental to achieve resilience to HIW. Open question: how far down the chain can the T-NAWDEX go? Downstream impact: wave breaking?

2) Summary of TNAWDEX workshop in Erding 2009 (George Craig)

T-NAWDEX proposed by PDP group: shift from targeted observations to a focus on physical processes and dynamics of weather systems. Initial plan for HALO mission in 2012 shifted due to issues with certification, etc. New target: 2016: a lot more confident.

Description of Agenda: Talks before lunch. Discussion based on structuring of the Erding 2009 workshop: Processes triggering wave guide, downstream evolution (PV structure, propagating, DRW), downstream impact of disturbances (wave breaking, local influence, what is controlled by this breaking events, what is not controlled on small scales). Campaign focused on synoptic scale with international collaboration: What do we want to measure?

3) UK contribution (John Methven)

Progress and ideas from DIAMET group: **DIAMET** work packages: A) Observations and modeling, B) Parameterization of physical processes, C) Predictability at the mesoscale.

2 DIAMET observation periods Nov/Dec 2011 May (wind storms, sting jets events), July/Aug 2012 (wettest year, flooding, rain falls). PV tracer analysis and diabatic modification of PV near the tropopause. Feature tracking in ensemble forecast.

Observational capabilities:

BAE 146 (new one contractor, operator not fixed, until end of 2013). Instrumentation: cloud probe (droplet distribution in mixed phase clouds), aerosol, and radiation. Short to medium range aircraft, Range of 4.5-5 h, science speed = 100 ms^{-1}, altitude ≈ 9km (300 hPa), deployment at US east coast or European side possible.

Ground based instruments: wind radar, wind profilers, lidars, radiosonde stations

Modeling capabilities: Operational (MOGREPS), case studies, tracers tool, WRF runs

UK Interests: 2way interaction mesoscale and cloud processes (diabatic processes), microphysics and dynamics interaction, systematic diabatic effects on synoptic scale evolution, slow moving cyclones (causing 2012 wet summer) and links to quasi-stationary Rossby waves

Timeline for T-NAWDEX 2016: Outline March 2014 for NERC large grant round, Dec 2014 full bid to NERC

4) US contribution (Chris Davis)

Proposed US component named **DOWNSTREAM** (Dynamics and Observations of the Waveguide: North–South Transport and Rossby wave Excitation over Atlantic Midlatitudes, self-contained project needed for application for **GV aircraft** (in service for 6 years)

Focus over eastern North America and the western North Atlantic. Scientific foci: stratospheric–tropospheric exchange; tropical, midlatitude, and polar forcing of waveguide perturbations, predictability, multi-scale interactions.

Combine various scales: synoptic hemispheric, meso-subsynoptic scale, microscale

Science Questions:

- Impact of Extratropical Transition on midlatitude flow (TC core vs. midlatitude frontal zone, convection and WCB like at baroclinic zone, observationally not confirmed),
- Polar Vortices (formation, representation, role of clouds, jet interaction),
- Predictability (NASA Outflow 2016 Global Hawk in Western Pacific, potential joint hemispheric observing period, wave trains, flooding). Water Vapor Transport (lower stratospheric water vapor, source regions), Cirrus Clouds (effects on PV, how can tracer correlations be used to understand larger scale dynamics, ice supersaturation, budget of water vapor)
- Water vapor transport at UTLS
- Cirrus clouds

Candidate for exemplary DOWNSTREAM case: ET of Leslie Sept 2012: Spans NA region

Aircraft GV operates at 41-43.000ft, flight duration of about 8 h, aircraft base: Bangor, Maine.

Instrumentation: W-Band Doppler Radar Clouds (Scan 15-20 degree angle, wind component normal to aircraft, in cirrus clouds, Water vapor, MTP (7-19 km, ~a few hundred m), Dropsondes, CVI residual of ice particle, Ozone, CO, other tracer species, Estimating PV from aircraft with radar wind and MTP temperature.

Canadian Aircraft Convair 580: microphysics, shorter range, based in Ottawa/St.Johns, Cloud Radar, flying in 0 to -20 °C temperature range which is important for diabatic processes.

Summary: Proposal due in Oct 2016, dynamics driven study of origin of waveguide perturbations, Fall 2014 decision expected, lots of interest in combining facilities (GV and HALO), collaborative opportunity

Discussion: PV METER; wind velocities, lidar (HALO) radar (GV) are complementary, intercomparison flights possible? diabatic processes US/CAN east coast

5) French contribution: (Veronique Ducrog, Gwendal Riviere)

HYMEX: Scientific interest: high impact weather downstream, Rossby wave breaking at end of storm track, convection within WCB, no HYMEX aircraft SOP in 2016. SOP level ground-based observations, high density rain observations, possible for T-NAWDEX, Support for operation coordination

EPIGONE program: Excitation, Propagation and impact on waveguide > Trajectories and deepening of extratropical storms, ET, Rossby wave breakings. New proposal DYNASTIE: predictability of waveguide, prepare TNAWDEX (decision June 2014)

OBSERVATIONS: Radar, Lidar, Dropsondes (Falcon), ATR, boundary layer balloons

FC PRODUCTS: for DIAMET, deterministic FC, radar, mesoscale FC, global ARPEGE, ENS, IASI, sensitivity to PV anomalies

6) German/Swiss Contribution (Andreas Schäfler)

PANDOWAE research on THORPEX topics at LMU, DLR and ETH, Overview on T-NAWDEX Falcon aircraft mission on WCBs in Nov 2012.

HALO status and next steps: HALO is a joint initiative of German environmental and climate research centers. Advisory board of all involved institutes decides about the deployment of HALO. November 2012: Selection and sequencing of campaigns 2014-16. T-NAWDEX presented as a joint initiative of LMU and DLR with a contribution of ETH: T-NAWDEX was selected and scheduled for 2016. Selected ≠ financed.

Research interests:

- Diabatic influences on upper level flow (Sensitivity of upper-level waveguide to the representation of WCBs, deep convection outflow, response to divergent forcing in a complex environment),
- Control of small scale variability,
- Relative roles of horizontal advection of humidity vs. surface fluxes vs. local vertical transport,
- Evolution of Rossby waves along the wave-guide,
- Data assimilation and forecast sensitivity,
- Links to other research areas/topics: gravity wave excitation, cirrus community, STE exchange

Instrumentation and logistics: Preferably operate from Oberpfaffenhofen (2 h transfer) due to high costs for external HALO campaign, operation region over eastern Atlantic. Preferably use certified instruments as a new certification of instruments is very expensive, Interest in HALO mission connected to the planned satellite mission ADM Aeolus, use airborne demonstrator instrument for wind observations in jet-stream region and to validate the space instrument:

ADM-demonstrator, 2 µm wind lidar, Dropsondes, Water vapor in-situ, Temperature (MTP), Trace gases (Ozone, CO, NOy), radiation

7) ML_CIRRUS (Christiane Voigt)

Investigate the climate impact from cirrus and contrail cirrus, Natural cirrus - **WCB Outflow** Cirrus, Measurement strategy for cirrus, instrumentation.

Mission facts: March - April 2014 (5½ weeks), 70 flight hours, HALO range, 14 km altitude, 8000km (10h flight hours), operation area over central and eastern Atlantic.

ML-CIRRUS links to T-NAWDEX: ML-CIRRUS can be used to optimize forecast and investigate forecast quality for flight planning, Development/improvement of flight strategy for WCBs, Instrumentation, Data in WCB outflow region

Discussion on data analysis with respect to dynamics: Role of Cirrus clouds (radiative processes) on PV distribution

8) UTLS (Peter Hoor)

Tracer based in-situ measurements, which process contributes most to transport in lower most stratosphere, Feedback chemical structure and thermodynamic structure on temperature structure, what is role of temperature on tracer distribution

- Does the Tropopause inversion layer (TIL) affect transport an mixing into the stratosphere and within the stratosphere?

  CO: background value well defined, 3 month lifetime, decay in stratosphere CO transport with WCBs, discontinuity of CO gradients

- Which factors determine the formation of the TIL and how do these affect transport
- Role of baroclinic life cycles, which factors are important for N2
- Which dynamical processes determine the chemical structure of the ExTL?

  Relation of chemical and dynamical structures at UTLS

- What is the role of stratospheric down welling of ozone for the TIL and the upper troposphere?

Powerful observations: medium lived traced, factors determine transport and distribution

Discussion of wind shear at TIL and role for vertical mixing

Plenary discussion I: Scientific goals

Proposed discussion based on Erding outcome:

1) Processes triggering wave-guide disturbances
    - PV anomalies in the stratosphere
    - Diabatic modification of airmasses in WCBs
    - ET of tropical cyclones
    - Orographic forcing
2) Evolution of Rossby waves along the wave-guide
    - Waveguide representation
    - Downstream evolution of PV anomalies
3) Downstream impact of diabatically modified PV anomalies
    - High impact weather downstream
    - Wave breaking sensitivity to upstream disturbances

Discussion about restructuring of the agenda: switch from processes that trigger the wave-guide to features triggering/modifying the wave guide disturbances and processes that influence these features (e.g. diabatically, chemically etc.)

1) Features and Factors triggering or modifying wave guide disturbances

Main points:

- PV anomalies in the stratosphere (polar vortices): diabatic influence, formation process + interaction and deformation of wave guide
- diabatic modification of air masses in WCBs (outflow neg. anomalies, diabatic PV generation)
- ET of tropical cyclones
- precursor wave packets: what was there already, amplified NA waves, different scenarios depending on type of wave packet

Comments:

- There might be no material connection at all between features, but rather a remote influence of the tropics (tele-connection)
- Orographic forcing is left out here. With 'orographic forcing' the influence of Greenland on the evolution of Rossby waves was meant, which fits under point 2.
- Also the propagation from land to sea can be meant, which is also in point 2.
- Preexisting wave-packets could be observed by routine operational network over NA

2) Evolution of Rossby waves along the wave-guide

Main points:

- waveguide representation
- downstream evolution of PV anomalies
- modification from Greenland
- local modification by PV anomalies

Comments:

- Where do forecast errors come in? → upstream
- what is setting properties of wave guide, set up of coast lines, gulf stream, propagation along wave guide
- Importance of diabatic processes which might already be in place, independently from the wave-guide which in turn can modify the disturbances
- From the western to eastern Atlantic there might be several (local) developments of different features, all influencing the Jetstream.

3) Downstream impact of diabatically modified PV anomalies

Main points:

- Wave breaking
    - sensitivity to upstream disturbances
    - different types of wave breakings
    - fine-scale aspects (filaments of PV), what gives predictability
- Wave breaking influences on synoptic features
    - blocking ridges
    - cutoff cyclones → heavy rain, convection
    - stationary troughs → heavy rain

Comments:

- Blocking is not necessarily wave breaking but at least a modified wave
- Nice chain to small scale weather systems

Possible contribution of others

Countries

- Canada: Needs funding application (timeline 1 year in advance), cloud sampling of mixed phase clouds, Alert within 3 days in advance, then one 2 week period possible, located in Canada
- Possibly there can be cooperated with other countries/areas more north/south, for

example Norway, the Mediterranean area (the HYMEX community, until 2020). Inform Thomas Spengler

- In France they try to develop nonlinear methods that improve predictability
- Ground based observations: Obs from HYMEX possible, UK ground based observations

Scientific areas of interest

- cirrus clouds
- transportation and tracers:
- polar region
- chemical impacts at tropopause

Comments:

- The polar region might also be interesting with regard to the sea-ice discussion
- Troposphere/Stratosphere transport, use with motivation to gain insight in the understanding of dynamics, passive tracers depend on underlying dynamics (vertical mixing), Chemistry is an entirely new area. If the motivation of the campaign is to improve models, than chemistry is far away and should not be a topic on it own, but rather a subtopic.
- Tracers from chemistry perspective might be useful for analyzing strat. intrusions
- Polar Prediction Project– polar vortices, sea-ice minimum, potential for longer time scales, Inform Thomas Jung about progress with TNAWDEX

Plenary discussion II: Logistic questions

As a summary of the discussion of the scientific questions some hypothesis were formulated:

Hypotheses

- Overarching hypothesis: there are systematic errors in model representation of waveguide perturbations
- These systematic errors are attributable to diabatic processes manifested as errors in PV distribution that corresponds to errors in the jet stream, which in turn lead to errors in forecasts high-impact weather downstream
- The contribution to error from disturbances is relative to their diabatic character (and scale)
- Predictability as measured by ensemble prediction systems is sensitive to diabatic processes?
- Predictability is dependent on the basic state of the waveguide
- Tropical source error differs from polar source error

Remaining comments and questions

- In all seasons there will be something interesting
- In autumn there be different situations as well (late summer, early winter)
- We should concentrate on a climatological interesting period
- What is the relationship between propagation of model error and initial conditions? → distinguish between errors and uncertainty
- ET is more uncertain → how much is it related to diabatic processes or dynamic processes?
- Sensitive regions → they have a different impact on the flow?!
- The hypotheses have to be tested by measurements
- Amplification can be under different triggering mechanisms → what is the relative distribution of different mechanisms?
- Getting obs in operational analysis in real time is beneficial to improve the product and helps to reach the set of goals of the experiments
- not only areas where HIW occurs are interesting, but also the regions where the largest uncertainties are found, i.e. where largest benefit can be gained from observations

Logistics

1. **Who are PIs? Who contributes to a T-NAWDEX white book (implementation plan)? / Who writes proposal for T-NAWDEX?**
   - Responsible people from US, Canada, UK, France, Germany are clear
   - What about Scandinavia people? → Thomas Spengler contact person
   - share international idea → collaborations
2. **What are the important deadlines?**
   - US: first cut in Aug → documents with needs, support letters required (e.g. DLR)
3. **How do we progress in the coming months?**
   - Formal phone conference schedule (last year: 4 conferences between UK, US, Germany) – monthly → Heini Wernli want to organize this
   - include more participants – a representative from each group → share documents
   - cyclone workshop Sept: meeting during this workshop? → evening session?

4. **What connections to related communities are desirable / in discussion?**
    - connection to modeling communities
    - ECMWF will remove data restrictions for field program participants - real time (operations) and archived data → connection beyond operational support
    - NCAR as field support management (forecast, analysis)
    - Remote sensing community (EUMETSAT, ESA – campaign section)
    - EUMET / Met-services: provided analysis errors are of interest; potential benefits for Met-services? → technical infrastructure
    - link to DWD / Météo France / UKMET for coordination? → investigate an errors
    - NASA-OUTFLOW? 3 year NASA project with Global Hawk on RW in Pacific, possible collaboration, P. Harr will establish linkage
    - Project ONR(?) on periods of reduced forecast accuracy
    - UTLS and cirrus cloud community → no question that they want contribute (are already involved) → link to warm conveyor belts
5. **Input to coming G-V/HALO Meeting**
    - meeting in the week after EGU in Mainz → technical meeting with scientific point about field campaigns (past and future) → talk about first combined mission (US, DLR, Germany)
    - Illustrative case – ET of Leslie?
    - Input from this meeting?
    - discussion with people on meeting → statement to organizers / ask where we go from here→ they are talking to steering committee?

Discussion and comments on Coordinated Project/Obs period:

- timing: 6 weeks at minimum, preferable 2 months
- September-October, but starting as late as 15. September and ending in early November could work
- location of operation center? → TBD likely to be two, UK on west side of Atlantic? Bermuda?

Summary

PRIMARY SCIENTIFIC ISSUES

- Factors triggering or modifying wave-guide disturbances
  - Tropopause polar vortices (pos. PV anomalies)
  - WCB outflow (neg. PV anomalies)
  - ET of tropical cyclones
  - Precursor wave packets
- Processes impacting wave-guide disturbances
- Evolution of Rossby waves along the waveguide
  - Waveguide representation
  - Downstream evolution of PV anomalies
  - Modification from Greenland
  - *Local* modification of Rossby waves by pos. and neg. PV anomalies
- Downstream impact of diabatically modified PV anomalies
  - Wave breaking
    - Sensitivity to upstream disturbances
    - Fine scale aspects
  - Wave breaking influence on synoptic features
    - Blocking ridges
    - Cutoff cyclones (anticyclonic w.b.)→Heavy rain/convection
    - Stationary troughs → Heavy rain
- Predictability issues?

HYPOTHESES

- Overarching hypothesis: There are systematic errors in model representation of waveguide perturbations.
- These systematic errors are attributable to diabatic processes manifested as errors in PV distribution that correspond to errors in the jet stream, which in turn lead to errors in forecasts of high-impact weather downstream.
- The contribution to error from disturbances is relative to their diabatic character (and scale).
- Predictability as measured by ensemble prediction systems is sensitive to diabatic processes.
- Predictability is dependent on the basic state of the waveguide.
- Tropical source error differs from polar source error.

LOGISTICS

- How do we progress in the coming months?
  - Formal phone conference schedule – monthly. Include more participants – a representative from each group
  - Share documents?
  - Meeting at Cyclone Workshop in September 2013 – evening session?
- What connections to related communities are desirable/in discussion?
  - Connection to modeling communities
    - EC will remove data restrictions for field program participants – real-time (operations) and archived data (post analysis)
  - NCAR as field support management (forecast, analysis, etc.)
  - Remote sensing community (EUMETSAT, European Space Agency)
  - EUMET, provided analysis errors are of interest to T-NAWDEX
  - DWD, METEOFRANCE, UKMET
  - UTLS and Cirrus cloud communities (already involved)
  - NASA OUTFLOW – how much to engage? – they may have decision by Jan 2014
  - Office of Naval Research initiative – periods of reduced forecast accuracy out to 14 days – a possible bridge between T-NAWDEX and NASA outflow
  - Input to the coming G-V/HALO Meeting in Mainz
  - Highlight that this would be first combined mission (U.S., DLR, Germany)
  - Illustrative case – ET of Leslie?
  - Send statement to organizers, ask where we go from here
  - Timing: 6 weeks at minimum, preferably 2 months. Sep-Oct, but starting as late as 15 Sep and ending in early Nov could work
- Op center: TBD, likely to be 2 (Bangor, ME?) UK on west side of Atlantic? Bermuda?

Participants:

Philippe Arbogast	GAMECNRM, CNRS and MétéoFrance, Toulouse, France
Heather Archambault	Naval Postgraduate School, Monterey, CA, USA
Susan Ballard	University of Reading, UK
Edmund Chang	School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY, USA
Jing Chen	Chinese Meteorological Administration, China
Kwanyoung Chung	National Institute of Meteorological Research/KMA, Korea
George Craig	Meteorological Institute LMU Munich, Germany
Ulrich Corsmeier	Institute for Meteorology and Climate Research, Karlsruhe Institute for Technology (KIT), Germany
Chris Davis,	National Center for Atmospheric Research, Boulder, Colorado
Andreas Dörnbrack	Deutsches Zentrum für Luft und Raumfahrt, Oberpfaffenhofen, Germany
Véronique Ducrocq	GAMECNRM, CNRS and MétéoFrance, Toulouse, France
Brian Golding	Met Office, Exeter, UK
Suzanne Gray	Department of Meteorology, University of Reading, UK
Patrick Harr,	Dept of Meteorology, Naval Postgraduate School, Monterey, CA, USA
Peter Hoor	Institute for Atmospheric Physics, University of Mainz, Germany
Christian Keil	Meteorological Institute LMU Munich, Germany
Julia Keller	Deutscher Wetterdienst, Offenbach, Germany
Stefan Klink	EUMETNET Observations Programme, Deutscher Wetterdienst, Offenbach, Germany
Christoph Kottmeier	Institute for Meteorology and Climate Research, Karlsruhe Institute for Technology (KIT), Germany
Benjamin Lamptey	Regional Maritime University, Nautical Department, Accra, Ghana
Mio Matsueda	University of Oxford, UK
Ron McTaggartCowan	Environment Canada, Dorval, Canada
John Methven	Department of Meteorology, University of Reading, UK
Tetsuo Nakazawa	WMO, Geneva, Switzerland

Oliver Reitebuch	Deutsches Zentrum für Luft- und Raumfahrt, Oberpfaffenhofen, Germany
Philipp Reutter	Institute for Atmospheric Physics, University of Mainz, Germany
Michael Riemer	Institute for Atmospheric Physics, University of Mainz, Germany
Gwendal Riviere	GAMECNRM,CNRS and MétéoFrance,Toulouse, France
Andreas Schäfler	Deutsches Zentrum für Luft und Raumfahrt, Oberpfaffenhofen, Germany
Peter Spichtinger	Institute for Atmospheric Physics, University of Mainz, Germany;
Juanzhen Sun	NCAR, Bolder, Co, USA
Richard Swinbank	Met Office, Exeter, UK
Bernhard Vogel	Institute for Meteorology and Climate Research, Karlsruhe Institute for Technology (KIT), Germany
Christiane Voigt	Deutsches Zentrum für Luft und Raumfahrt, Oberpfaffenhofen, Germany
Martin Weissmann	Hans Ertel Centre for Weather Research, Ludwig Maximilians Universität München, Germany
Heini Wernli	Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland

Further persons that should be informed:

Thomas Jung, Thomas Spengler, Chris Velden, Hans Volkert, Victor Homar, Sim Aberson, Beth Ebert, Andreas Wieser