

The US THORPEX Science Plan



6TH NAEFS WORKSHOP
Monterey, CA, May 2, 2012



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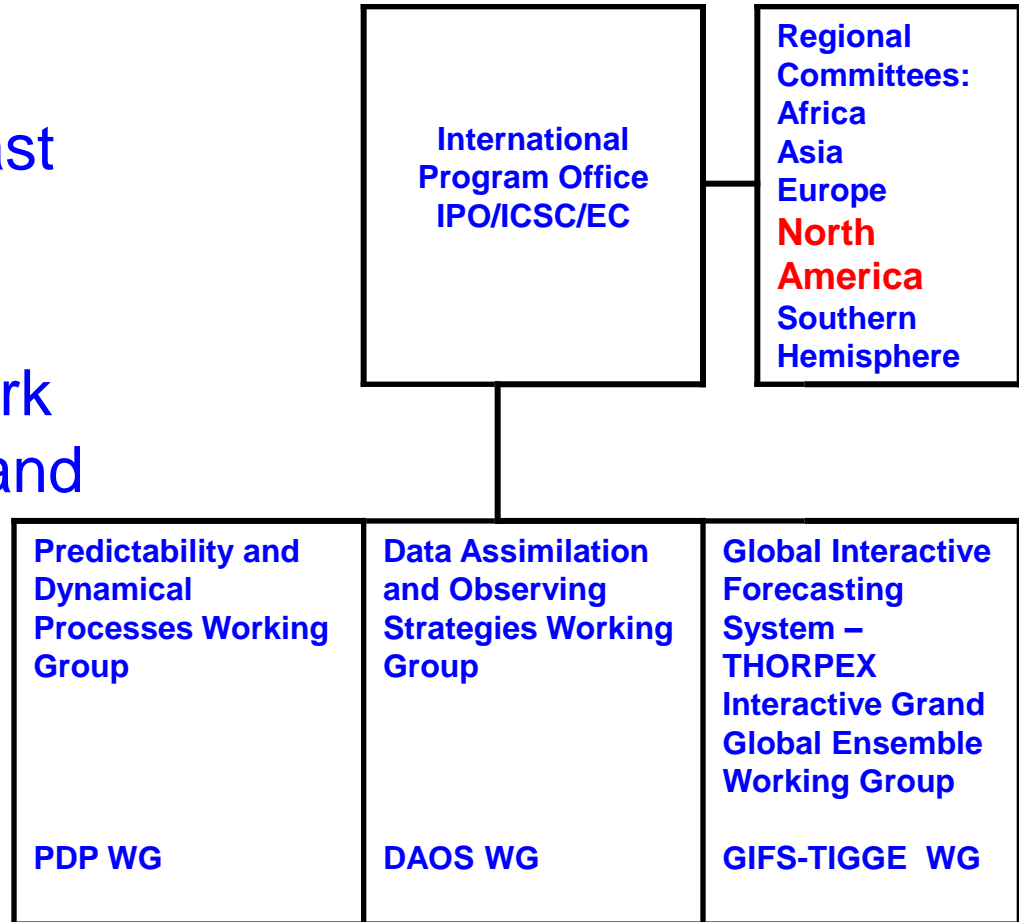
The Science Plan

- Prepared by the US THORPEX Science Steering Committee^[1]
- A living document
- Most recent version (Nov 2010) posted at <http://www.ucar.edu/na-thorpex/documents/US>
- Was approved by the US THORPEX Executive Committee

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Int THORPEX: Goals and Structure

- Better high impact weather forecasts
- Effective use of forecast products.
- International collaboration framework for weather research and forecast solutions
- Three communities: academic institutions, operational forecast centers and users of forecast products.



US THORPEX Structure

USTEC

NAVY

NOAA

NASA

NSF

USSTC

SUNY
UMD
NCAR

NCEP
NASA
NRL

Private

Reconstituted last year

International THORPEX Priorities

- Global-to-regional influences on the evolution and predictability of weather systems
- Global observing-system design and demonstration
- Targeting and assimilation of observations
- Effective use of ensemble/probabilistic forecasts
- Societal, economic, and environmental benefits of improved forecasts

US THORPEX approach

- Improving the skill and utility of forecasts of high-impact weather is one of the great scientific and societal challenges of the 21st century
- Greater societal benefits is sought in a more probabilistic, ensemble-based approach to forecasting
- Advances in our ability to forecast the likelihood of high-impact weather, and advances in our understanding of forecasts that have high-impact, will provide important, new support to decision makers and planners.

Examples of high-impact events

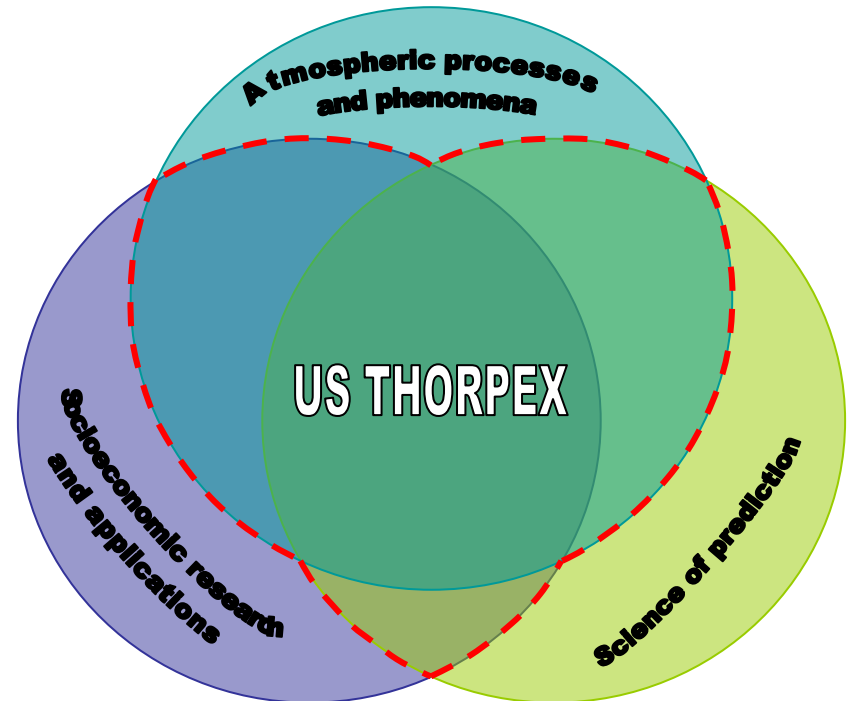
Condition	Annual average*	Maximum events	Date
Tornadoes	82–100	739 322	Mar 1925 Apr 1974
Heavy rains and floods	100–160	2200 732	May 1899 Mar 1913
Hurricanes	38–63	6000 1836	Sep 1900 Sep 1928
Hail	1	22	May 1981
Windstorms	60–115	105	Dec 1972
Lightning	100–156	Unknown	—
Winter storms and cold	130–200	500 270	Dec 1983 Mar 1992
Heat waves	1000	>10 000 > 9500	1980 1901
*ranges reflect data from various sources			

Table 1: Number of deaths directly attributed to weather in the United States (source: Changnon et al. 1996).

US THORPEX Research Areas

Three research communities have self-organized to respond to the THORPEX challenge and produce whitepapers that outline important research directions: i) improved understanding of atmospheric processes and phenomena, ii) advances in the science of prediction, and iii) socio-economic research and applications.

US THORPEX is interested in the intersection of two or even all three



Forecast span

- Emphasis on the 1-14 days range forecasts
- Recognizing the multi-scale nature of the atmosphere system: In order to improve forecasts in week two it is necessary to improve analyses, 6hr forecasts, 1 day forecasts, etc., because short-lead forecast errors grow to impact long-lead forecast efforts.
- There is no hard barrier at day 14. Challenges associated with the long-lead weather forecast problem are shared by the 15-90 day intra-seasonal forecast problem.

Atmospheric processes and phenomena

- *Tropical/Extratropical interactions*
- *Extratropical transition (ET) of tropical cyclones (TC)*
- *Tropical processes*
- *Polar/Midlatitude interactions*
- *Aerosols*

The science of prediction

- *Observing systems*
- *Data Assimilation*
- *Reducing and accounting for model inadequacy*
- *Intrinsic midlatitude predictability*
- *The error dynamics of ensemble prediction systems*

Socio-economic research and applications (SERA)

- *Use of forecast information in decision making*
- *Communicating forecast uncertainty*
- *User-relevant verification*
- *Quantifying the value of forecasts*
- *Developing decision support tools and systems*



Collaboration with International efforts

- *The THORPEX Interactive Grand Global Ensemble (TIGGE) and the Global Interactive Forecast System (GIFS)*
- *The Global Earth Observation System of Systems (GEOSS)*
- *North American Ensemble Forecast System (NAEFS)*
- *The THORPEX Pacific Asian Research Campaign (T-PARC) and Tropical Cyclone Structure-2008 (TCS-08)*
- *African Monsoon Multidisciplinary Analysis (AMMA)*
- *International Polar Year (IPY)*
- *Year of Tropical Convection (YOTC)*

Collaboration with International efforts

- ESPC (Earth System Prediction Capability) out to subseasonal (20yrs plan)
- Two new WWRP projects beyond THORPEX: Polar prediction and Subseasonal

Collaboration with National efforts

➤ *The National Unified Operational Prediction Capability (NUOPC)*

- An agreement between the US weather services to collaborate on coordinated research and development and ensemble operations.
- To expand on the NAEFS ensemble to provide a managed ensemble system including common post processing.
- To develop a common NWP research agenda and align transition processes to accelerate the transition of research into operations.

➤ *The NOAA Hurricane Forecast Improvement Project (HFIP)*

NAEFS

NOAA-Funded Projects

- Ensemble Initial Perturbations and Development of Hybrid Data Assimilation System.
- Extensions and Improvements to the NAEFS Post-Processor at NCEP/EMC.
- Development and Operational Implementation of A Stochastic Perturbation Scheme in GEFS.
- Improving high impact weather forecasts by adaptive observing, data processing.

Operations and Observation Strategies



THORPEX-Pacific Asian Regional Campaign (T-PARC)

THORPEX (The Observing-System Research and Predictability Experiment)

And

Tropical Cyclone Structure-08 Experiments (TCS-08)

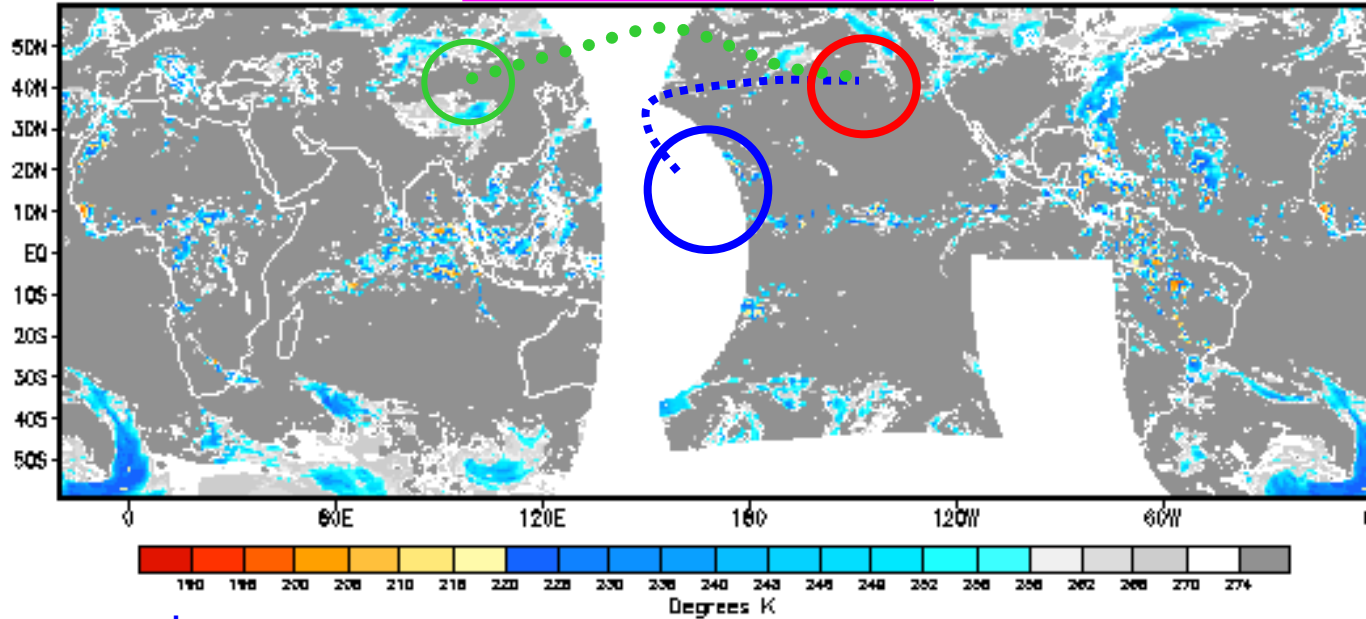
Collaborative Efforts

MAIN THEME OF WINTER T-PARC

Study the lifecycle of perturbations as they originate from the tropics, Asia, and/or the polar front, travel through the Pacific waveguide, and affect high impact wintertime weather events over North America and the Arctic

Youcheng Song (NCEP)

20:30Z 07 OCT 2005



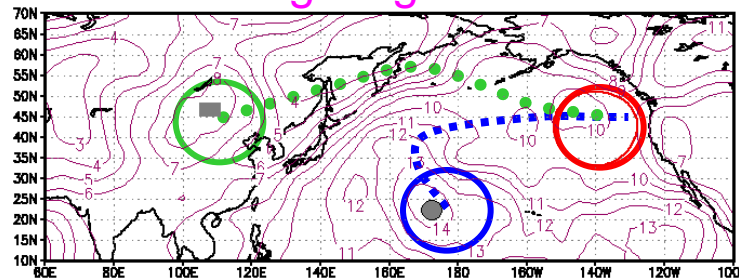
Tropical flare-ups in western Pacific (IR) merge with

Waves on westerly flow to influence

Deep cyclogenesis in northeast Pacific

Expected forecast error reduction in verification region (VR) due to adaptive observations around any grid point.
Case 1 Obs. time: 2005101100 Verif. time 2005101412 VR: 42N, 140W, 1000km radius Verif. var.: u,v,T
PSU-NCEP ETKF based on 19-member 2005101000 NCEP ensemble.

Captured by Ensemble Transform KF targeting method



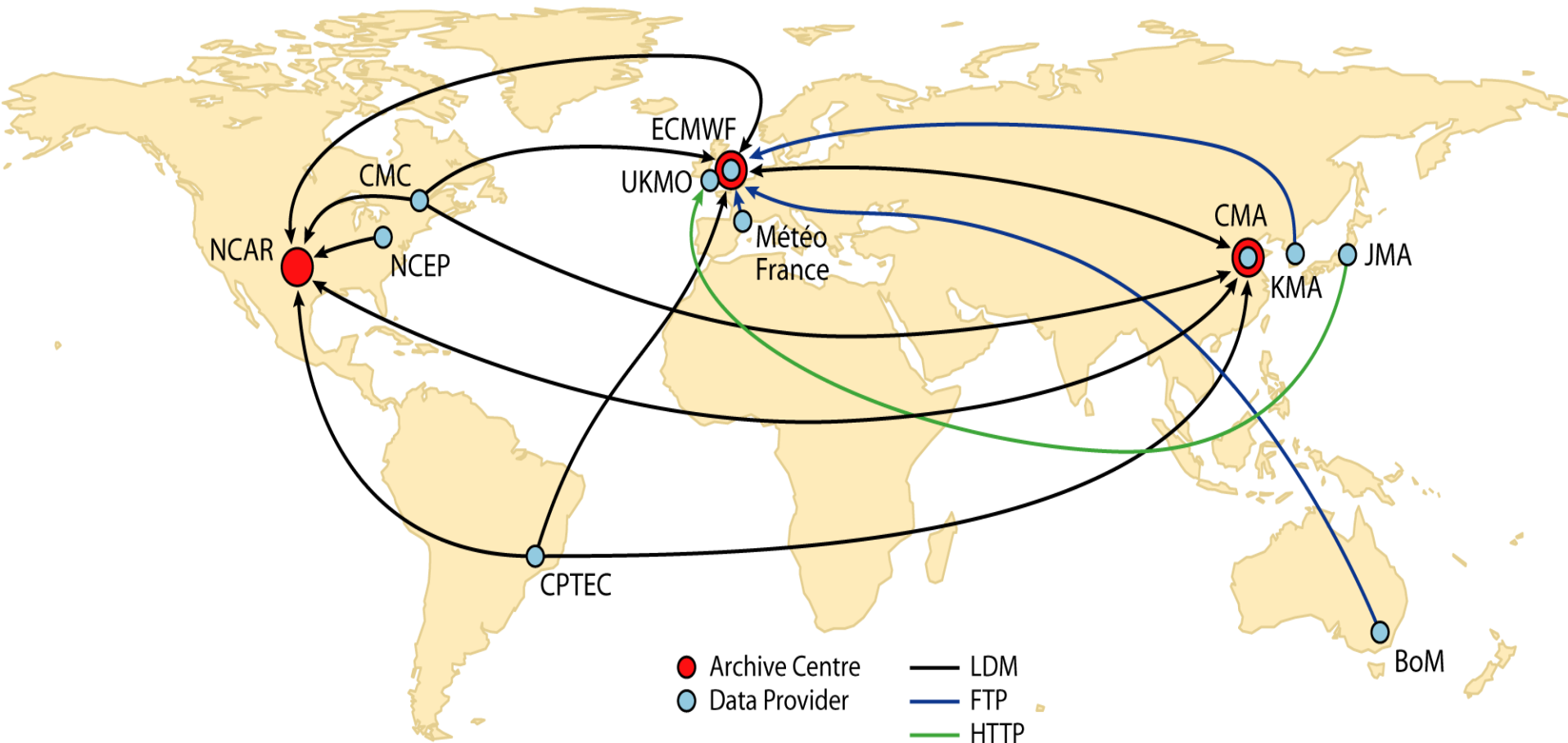
○ Sensitive area 1, 00UTC 11 Oct

○ Sensitive area 2, 00UTC 11 Oct

○ Verification region, 12UTC 14 Oct

TIGGE Data Delivery (02/2010)

- Data exchanges using UNIDATA LDM, HTTP and FTP
- 440 GB/day (ECMWF = 332 GB/day)
- 1.7+ million 2-D gridded fields/day



GIFS Plans (not realized)

GIFS PRODUCTS

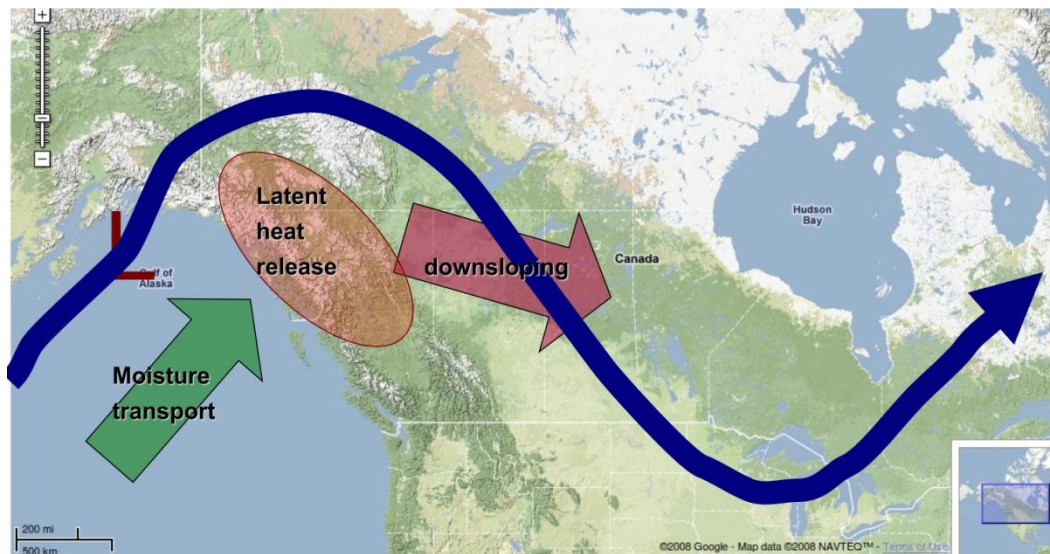
- Produce internationally coordinated advance warnings and forecasts
 - For high impact weather events
 - To mitigate loss of life and property
 - To contribute to the welfare of all WMO nations
 - With a particular emphasis on least developed and developing countries
- Apply ensemble prediction systems for
 - Assessing and mitigating weather and climate related risks by
 - Quantifying forecast uncertainty

END-TO-END GIFS

- Provide guidance on & coordinate use of
 - Observational
 - Numerical data assimilation
 - Forecasting
 - User application resources
 - To ensure the highest quality guidance for high impact weather events

Arctic Research

- Study impact of moisture transport to high latitudes along “atmospheric rivers”
 - Heavy precipitation over the windward slopes of the Western Cordillera
 - Downsloping in the lee may lead to persistent ridging over the Canadian north and the onset of drought conditions



Flow pattern associated with diabatic ridge development over the Canadian Arctic and Praries in association with heavy coastal precipitation events.

Short-Term Focus

➤ T-PARC observations:

- Tropical/extratropical interactions and the extratropical transition of tropical cyclones. Process and phenomena scientists can partner with science of prediction researchers to bring to bear new tools to help address the science questions. Increased understanding of the relevant processes will then find their way into operational models where their impact could be assessed both in terms of traditional forecasting measures, but also using SERA-relevant measures.

➤ The TIGGE dataset:

- especially relevant for the error dynamics of ensemble prediction systems and research into model inadequacy

Medium-Term Focus

- Tropical processes, especially those likely to have midlatitude impacts
- Opportunity to consider midlatitude predictability issues other than ET
- The role of the polar region on high-impact forecast
- Efforts to take state-dependent uncertainty into account in data assimilation and verification
- to focus on the use of forecast information in decision making

Long-Term Focus

- thrusts build upon results and collaborations obtained through the short- and medium-term research efforts
- extend the polar/midlatitude and tropical/midlatitude research efforts and strive to understand the coupled interactions between the tropics, poles, and midlatitudes
- understand and quantify the impact of aerosols on aspects of the tropical Pacific, and on high-impact weather forecasts over the US
- integrate SERA activities with combined atmospheric process and phenomena and science of prediction efforts

The US Science Steering Committee

- A 10-member Committee recently formed to reinvigorate US THORPEX activities
- First steps include to produce an implementation approach of the scientific plan, in particular articulate and strengthen the SERA initiative
- A workshop is being schedule for the Fall 2012 with the main purpose to define research priorities and a road map to move forward along new initiatives (e.g. NWS's weather ready nation)