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Using Normalized Anomalies To Classify Extratroipcal – Tropical Interactions

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A normalized anomaly framework is presented for both a historical atmospheric reanalysis dataset and coupled-climate model output. Here, extreme events are assessed against the backdrop of the evolving climatology. Phenomena such as tropical cyclones undergoing extratropical transition or equatorially-migrating cut-off low pressure systems exemplify highly anomalous atmospheric states for a given time and space. These anomalies include geopotential height depressions, mid-troposphere temperature heat-pools, and columnar moisture pathways from the tropics to the midlatitudes.

Data

NCEP/NCAR Reanalysis (Kalnay et al. 1996) 1957-2006 used for climatology: 50 years.

ECHAM5v2.02 T63/N48 L31 6h data Run 1 (Roeckner et al. 2003) SRESA1B (2001-2030) and (2061-2090). Bengtsson et al. (2006) investigated the effects of climate change on storm tracks using the ECHAM5 coupled climate model and found the simulations indicative of past climate (when compared to ERA40).

Normalized Anomalies

Define the "mean state": 21-day running mean (1957-2006) at 00Z, 06Z, 12Z, 18Z (individual times are not combined). Calculate the standard deviation from this long time period mean. (21 x 50= 1050)

$$N = (X - \mu)/\sigma$$

N is the distribution of the "normalized departure from climatology" in **sigmas**. (Hart and Grumm 2001). "X" is the chosen atmospheric variable to be normalized.

Scalar fields such as geopotential height, temperature, precipitable water, sea-level pressure, wind magnitude, and SST are readily expressed in terms of normalized anomalies.

ECHAM5 data used include 500 hPa Temperature, 500 hPa Geopotential height, MSLP, and 925 hPa wind magnitude.

Advantages

Evolving climatology – both spatially and temporally

No longer hampered by monthly means

Allow for easy synoptic-scale analysis and detection of phenomena and distributions of extreme events.

Objective characterization of events: historical implications, return periods, frequency changes through time, climate impacts.

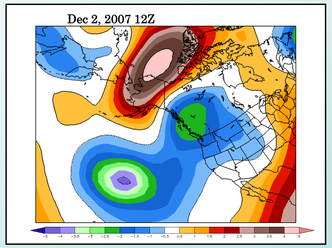
Disadvantages

Data intensive, require daily or many-times daily atmospheric fields.

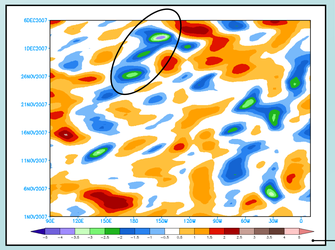
Skewness of distribution is not considered.

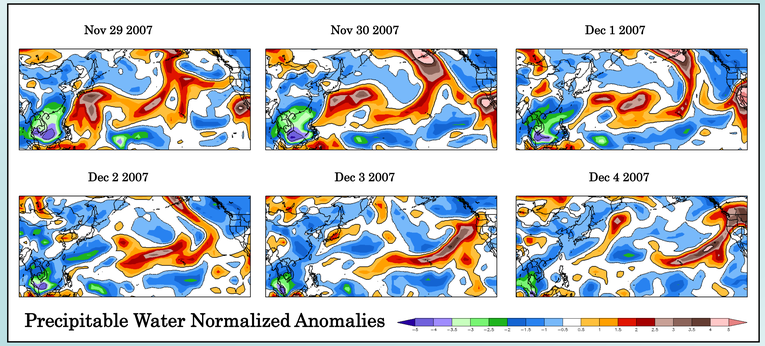
Data record of 50 years is still insufficient to historically compare tropical cyclones, which are extreme anomalies against the background.

2007 Pacific Tropical – Extratropical Moisture Pathway



500 hPa Geopotential Height Normalized Anomalies

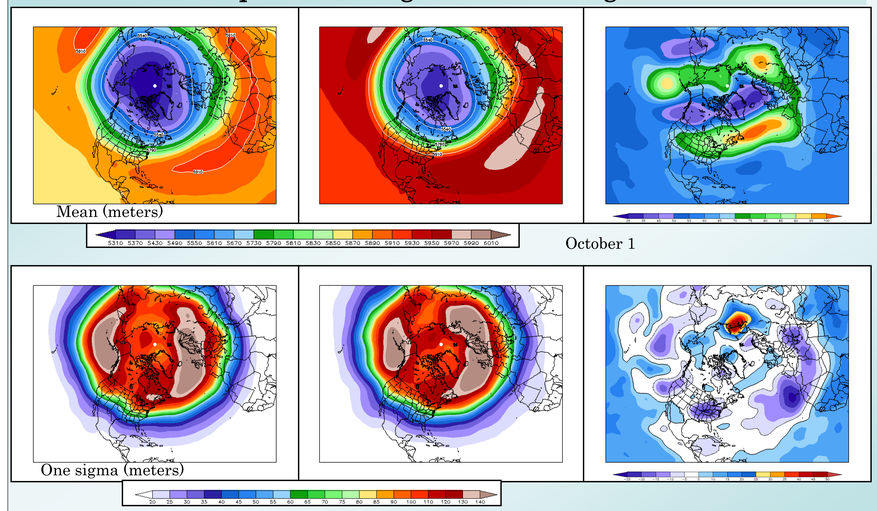




Typhoons Hagibis and Mitag did not recurve due to a strong poleward upper-level ridge. The enhancement of the intervening jet stream through diabatic processes fueled several extratropical storms along the main storm track. Their warm-conveyor belts tapped into the heat/moisture pool left behind by the remnant typhoons, and developed a historically-anomalous ridge over the Arctic (top left). A very deep 500 mb trough centered north of Hawaii accentuated the precipitable water freeway, which resulted in a very powerful pressure gradient along the Oregon/Washington coasts. Considerable flooding and wind damage resulted from the coastal warm seclusion.

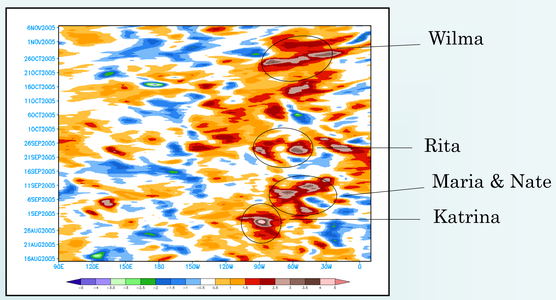
Latitudinal Average from 30°-35°N: NCEP/NCAR Reanalysis (Climatology 1957-2006)

500 hPa Geopotential Height Mean and Sigma: ECHAM5

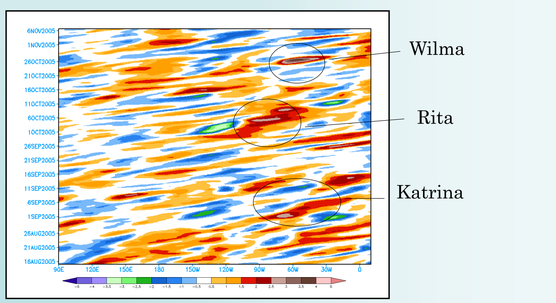


Recurving Tropical Cyclones

300 hPa Temperature Normalized Anomalies



Latitudinal Average from 25°-30°N (NCEP/NCAR Reanalysis)

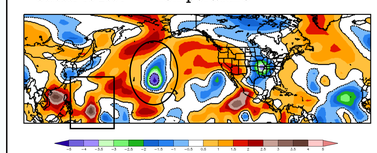


Latitudinal Average from 45°-50°N

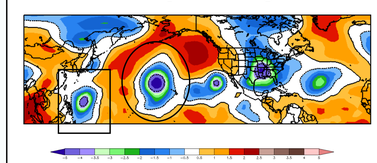
Cold-Core Cut-off Depressions

500 hPa Temperature and Geopotential Anomalies

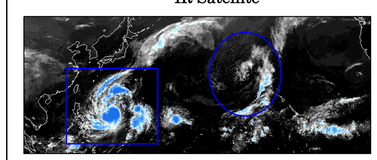
October 15 2004 **Temperature**



October 15 2004 **Geopotential Height**

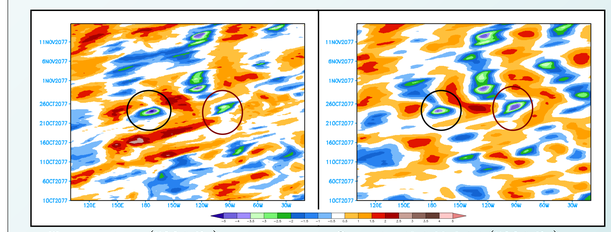


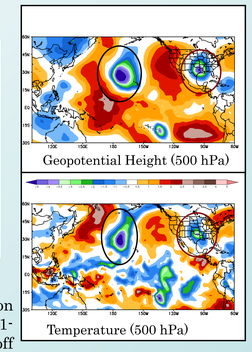
IR Satellite



Typhoon Tokage

ECHAM5 simulated climate (A1B)





Normalized Anomalies during a selected October period of 2077 (A1B emission scenario) are based upon the background climatology developed between 2061-2090 (30 years, 21 day running mean). The black (red) circles indicate cut-off low cold-core depressions originating from higher latitudes. (30°-35°N average)

Prior to the snapshot of geopotential height (top right) and temperature (bottom right), a powerful model-generated Typhoon underwent extratropical transition and contributed to the highly-amplified downstream long-wave pattern.

Conclusions and research trajectory

With an evolving climatology normalized anomaly framework, the frequency, intensity, and distribution of anomalous or extreme events can be quantitatively analyzed. Results from ECHAM5 for a simulated period indicate plenty of extreme events that deserve future exploration.

With NCEP/NCAR reanalysis (or its cousins: ERA40 & JRA25), apply a systematic tracking and detection method for large-scale features as tropical cyclones, cut-off lows, blocks, and other anomalous events.

Compare control runs (i.e. 20th century) of the ever-growing ensemble of coupled climate simulations.

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Real-time GFS normalized anomalies at http://www.coaps.fsu.edu/~maue/weather