Summary Jangmi

- net transport of low PV air to tropopause determines **direct impact** of ET

- existence of critical **bifurcation point** for track of Jangmi

- relative position of Jangmi an midlatitude flow determines **downstream impact** of ET
The key role of diabatic processes in modifying the upper-tropospheric wave guide

Christian M. Grams\textsuperscript{a*}, Heini Wernli\textsuperscript{b}, Maxi Böttcher\textsuperscript{b}, Jana Čampa\textsuperscript{c}, Ulrich Corsmeier\textsuperscript{a}, Sarah C. Jones\textsuperscript{a}, Julia H. Keller\textsuperscript{a}, Claus-Jürgen Lenz\textsuperscript{a}, Lars Wiegand\textsuperscript{d}

\textsuperscript{a} Institute for Meteorology and Climate Research (IMK-TRO), Karlsruhe Institute of Technology, Karlsruhe, Germany
\textsuperscript{b} Institute for Atmospheric and Climate Science, ETH Zürich, Zürich, Switzerland
\textsuperscript{c} Institut für Physik der Atmosphäre, Universität Mainz, Mainz, Germany
\textsuperscript{d} Institute for Climate and Atmospheric Science, School of Earth and Environment, University of Leeds, Leeds, UK
Motivation: HIW in Europe

9 September 2008
- cyclone downstream of Hanna
- 61mm

10 September 2008
- Ex-Hanna
- 28mm

11 September 2008
- Ex-Hanna’s cold front
- 68mm

12 September 2008
- large-scale lifting
- 88mm

13 September 2008
- Med. cyclone Olivia
- 228mm
Motivation: reduced predictability

Standard deviation [gpm] of geopotential height [gpm] at 200 hPa 40-60°N

- Downstream ridge/trough
- Upstream ridge
- PV streamer upstream

- Hanna
- \( L_{\text{up}} \)

Longitude, time, PV streamer, TIGGE ensemble
Synoptic overview

12 UTC 7 September 2008  IPV at $\theta=320$K, mean sea level pressure

L Hanna
Synoptic Overview

12 UTC 8 September 2008  IPV at θ=320K, mean sea level pressure
Synoptic Overview

12 UTC 9 September 2008  IPV at $\theta=320\text{K}$, mean sea level pressure
Synoptic Overview

12 UTC 10 September 2008  IPV at \( \theta = 320K \), mean sea level pressure
Synoptic Overview

12 UTC 11 September 2008
IPV at $\theta=320K$, mean sea level pressure
Synoptic Overview

12 UTC 12 September 2008  IPV at $\theta=320K$, mean sea level pressure
Synoptic Overview

12 UTC 13 September 2008  IPV at $\theta=320K$, mean sea level pressure
direct impact: PV surgery

similar to Jangmi transport of very low PV air into ridge at jet level
ridgebuilding downstream (-7 PVU)
increased tropopause PV gradient, accelerated jet
downstream impact

1. up to 50mm more P in UK in CNTRL linked with downstr. cyc. and Hanna
2. correct eastward track of Olivia and P > 75mm
3. different Med. cyclone in NOTC
4. > 75mm P linked with cut-off of downstream trough

more P in NOTC
more P in CNTRL
Interplay of WCBs

- wrap up of low PV air in Ex-Hanna
- transport of low PV by WCB of upstream cyclone

→ Elongation of PV streamer

- WCB ahead of trailing cold front
  → PV cut off
Vertical PV profile and diabatic processes

00 UTC 7 Sep 2008

vertical cross section

PV at 850 hPa

• tropical PV tower approaching BZ

ET-Hanna
Vertical PV profile and diabatic processes

00 UTC 9 Sep 2008

vertical cross section

PV at 850 hPa  PV at 320 K

new PV band

remnant tropical PV

• tropical low-level PV leads to advection against baroclinic zone
  → diabatic PV production
• new PV core

ET-Hanna
Vertical PV profile and diabatic processes

12 UTC 9 Sep 2008

vertical cross section

PV at 850 hPa

• low-level PV vertically aligned with upper-level trough

ET-Hanna
Vertical PV profile and diabatic processes

00 UTC 10 Sep 2008

vertical cross section

PV at 850 hPa

- low-level PV vertically aligned with upper-level trough

ET-Hanna
Vertical PV profile and diabatic processes

00 UTC 9 Sep 2008

• pronounced upper-level trough

upstream cyclone
Vertical PV profile and diabatic processes

00 UTC 10 Sep 2008

vertical cross section

PV at 320K

- diabatic PV production at mid and low levels

upstream cyclone
Vertical PV profile and diabatic processes

00 UTC 11 Sep 2008

- vertical alignment

upstream cyclone
Vertical PV profile and diabatic processes

Vertical profiles of PV averaged within a 200km radius

ET-Hanna

upstream cyclone

![Graph showing vertical profiles of PV averaged within a 200km radius for ET-Hanna and an upstream cyclone.](image-url)
Summary Hanna

- Dynamic links between ET system, midlatitude waveguide and Mediterranean cyclogenesis
- Role of diabatic processes in WCBs in the evolution of a PV streamer
- Role of diabatic processes in the modification of the vertical structure of cyclonic vortices

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Typhoon Choi-Wan (2009)

- merging with extratropical cyclone to NE
- amplification of downstream RWT
- shift of second downstream ridge / trough
Typhoon Lupit (2009)

- explosive extratropical reintensification
- strong amplification of downstream ridge/trough
- less pronounced in NOTC run, but similar development
Typhoon Malakas (2010)

- RWT triggering less pronounced in NOTC
- link to heat wave in southern California (L.A.) and heavy precipitation at US East coast?
direct impact all cases

PV@340K control – no TC

- net transport of low PV air to tropopause in all cases

downstream impact in strong ET cases:
- amplification of RWT
- delay of eastward RW propagation
Choi-Wan (2009)

Low-level (975-850hPa) PV in PVU and pmsl in hPa 00Z 16 Sep 2009

DRV?

Choi-Wan
Choi-Wan (2009)

low-level (975-850hPa) PV in PVU and pmsl in hPa 12Z 17 Sep 2009
Choi-Wan (2009)

low-level (975-850hPa) PV in PVU and pmsl in hPa 00Z 19 Sep 2009
Choi-Wan (2009)

pmsl (in hPa)
Choi-Wan (2009)

low-level (975-850hPa) PV in PVU and pmsl in hPa 00Z 20 Sep 2009
Choi-Wan (2009)

low-level (975-850hPa) PV in PVU and pmsl in hPa 12Z 20 Sep 2009
Choi-Wan (2009)

low-level (975-850hPa) PV in PVU and pmsl in hPa 00Z 21 Sep 2009
Choi-Wan (2009)

low-level (975-850hPa) PV in PVU and pmsl in hPa 12Z 21 Sep 2009
Choi-Wan (2009)

- altered 2nd downstream ridge over western North America
- shifted 2nd downstream trough

analysis       control       no TC

340K, 2PVU 00UTC 23.9.2009 +144h
Choi-Wan (2009)

\( +143 \text{h, 23 UTC 22 September 2009} \)

2m temperature
Choi-Wan (2009)

- early cool air outbreak
- late heat wave West Coast
- northward shifted precipitation

2m temperature Denver airport

2m temperature Seattle airport
Reduction in predictability

- 5 case studies of ET
- average predictability reduction due ET: 2 – 2.5 days
Summary

- Hanna case study diabatic modification of upper-level wave guide
- net transport of low PV air to tropopause determines **direct impact** of ET
- strong ridgebuilding/reintensification results in amplification and westward displacement of **downstream** RWT
- average reduction in predictability 2 days
Warm conveyor belts (WCB)  
(Browning 1990, Eckhardt et al. 2004, Wernli and Davies 1997)

- rapidly ascending cross isentropic air flows (>600hPa/2d)
- diabatic heating of about 20K / 2 days
- diabatic PV production below level of maximum heating
- diabatic PV reduction and low PV values at upper levels

(after Wernli and Davies 1997)