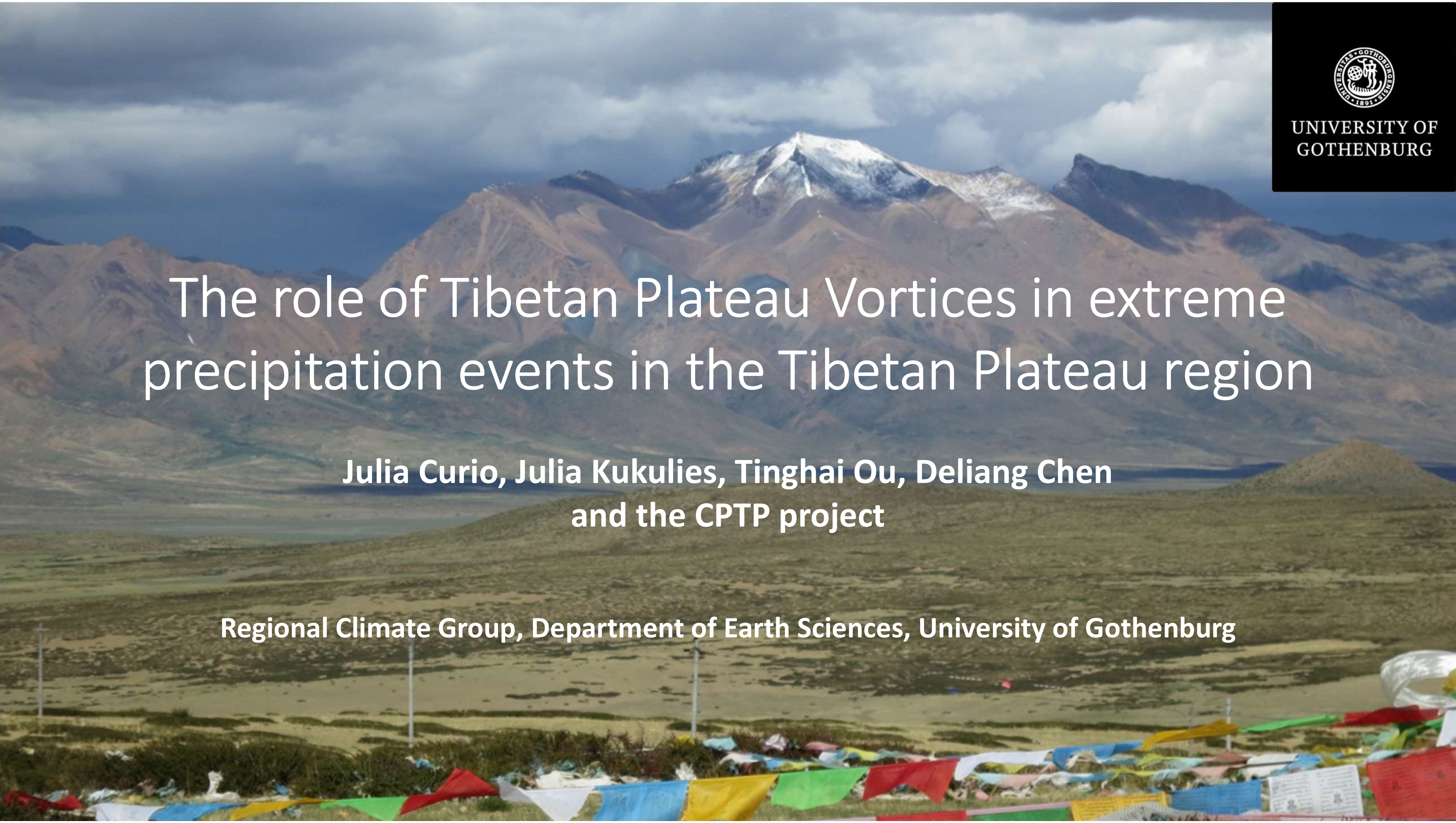


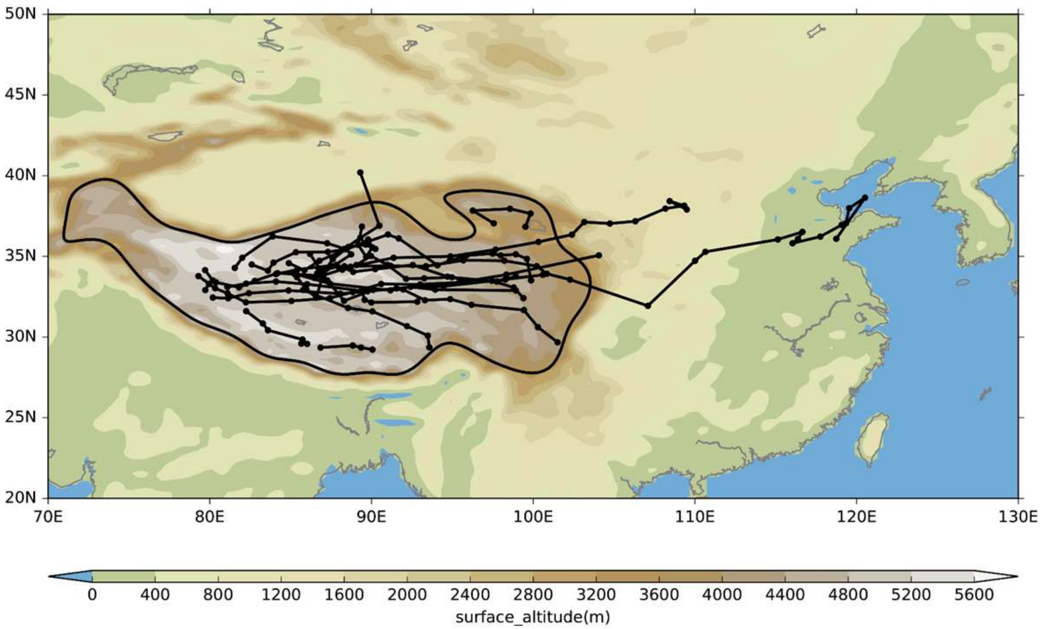
The role of Tibetan Plateau Vortices in extreme precipitation events in the Tibetan Plateau region

Julia Curio, Julia Kukulies, Tinghai Ou, Deliang Chen
and the CPTP project

Regional Climate Group, Department of Earth Sciences, University of Gothenburg

UNIVERSITY OF GOTHENBURG

Tibetan Plateau Vortices (TPVs)



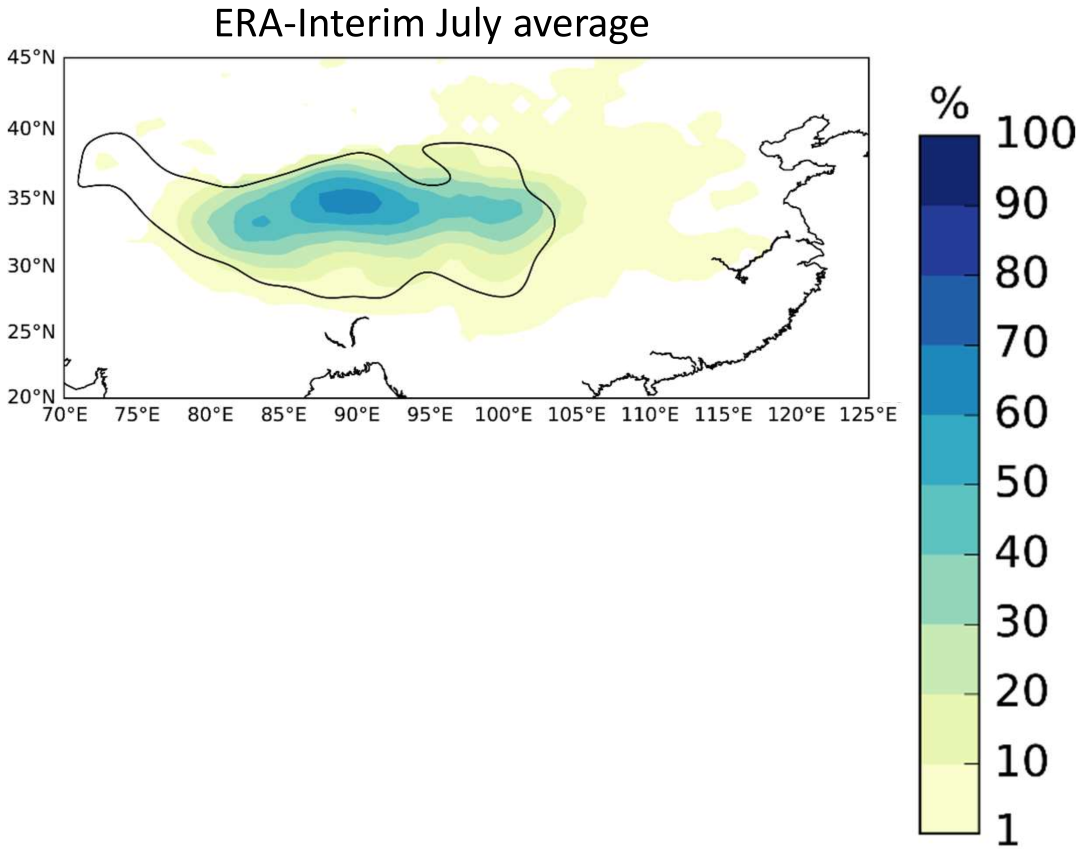
Curio et al. 2019, Journal of Climate

- Frequent phenomena
- Mainly present at 500 hPa level
- Spatial scales

  horizontal: Meso-α-scale, 400-800 km

  vertical: 2-3 km
- Pronounced annual cycle with maximum occurrence frequency in summer and minimum in winter
- Move eastward from their genesis region in a band of high track densities along 34° N, connection to the jet stream
- Only a minority of TPVs move off the Tibetan Plateau

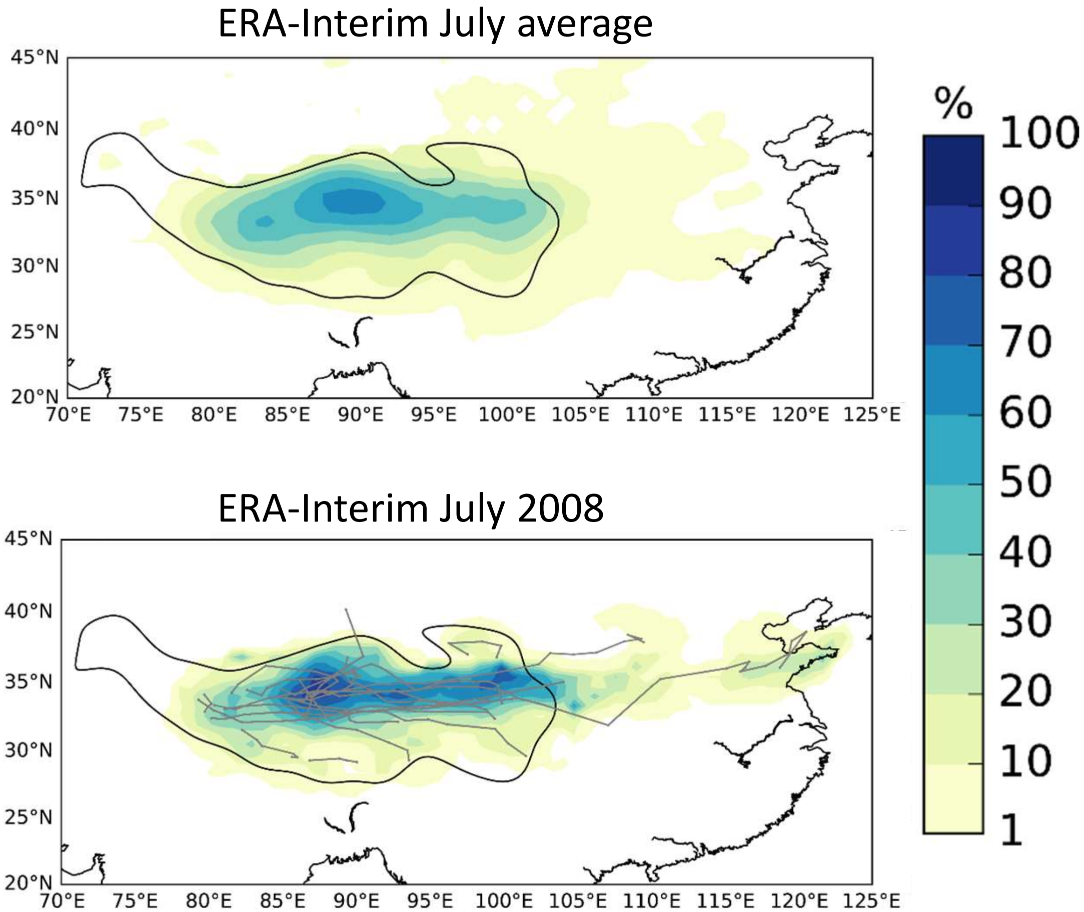
Precipitation contribution



- TPV-associated precipitation accounts for up to 70% of the total monthly precipitation on the TP
- Contribution downstream up to 10%, up to 20% at the edge of the TP

Curio et al. 2019, Journal of Climate

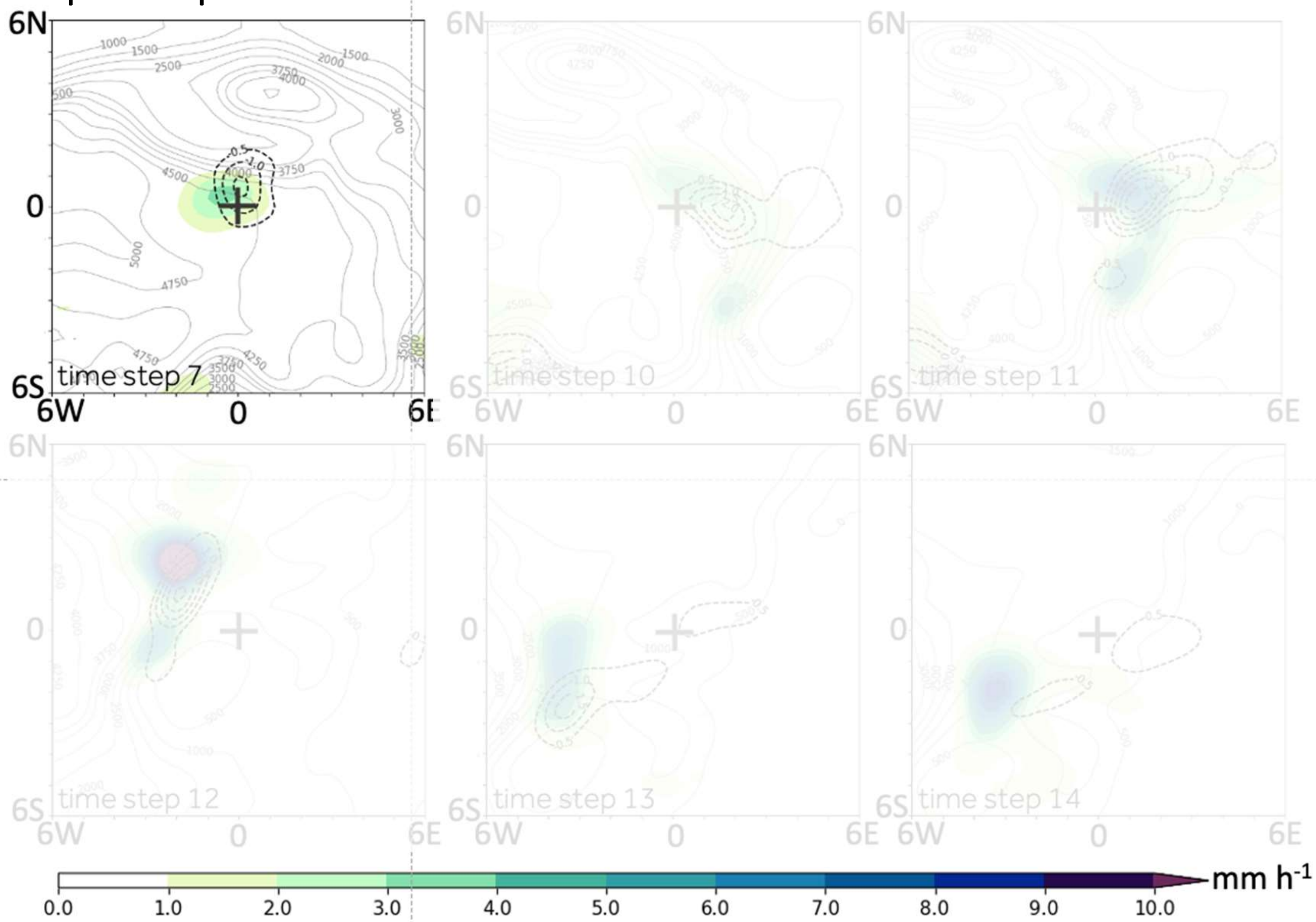
Precipitation contribution



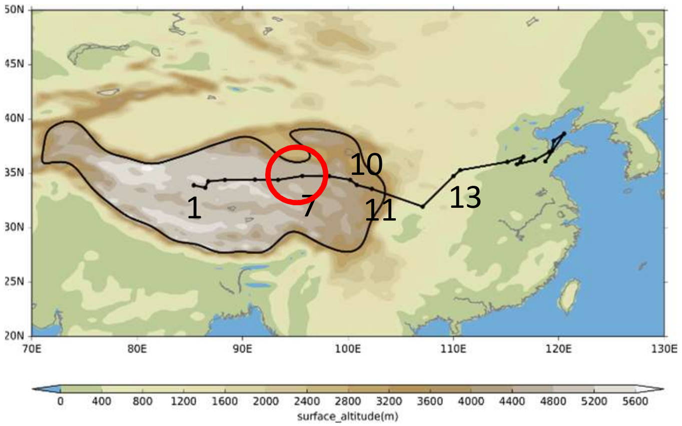
Curio et al. 2019, Journal of Climate

- TPV-associated precipitation accounts for up to 70% of the total monthly precipitation on the TP
- Contribution downstream up to 10%, up to 20% at the edge of the TP
- For individual months, the contribution can be much higher in some downstream regions, mainly due to single TPV events
- These moving-off TPVs can trigger extreme rainfall and severe flooding

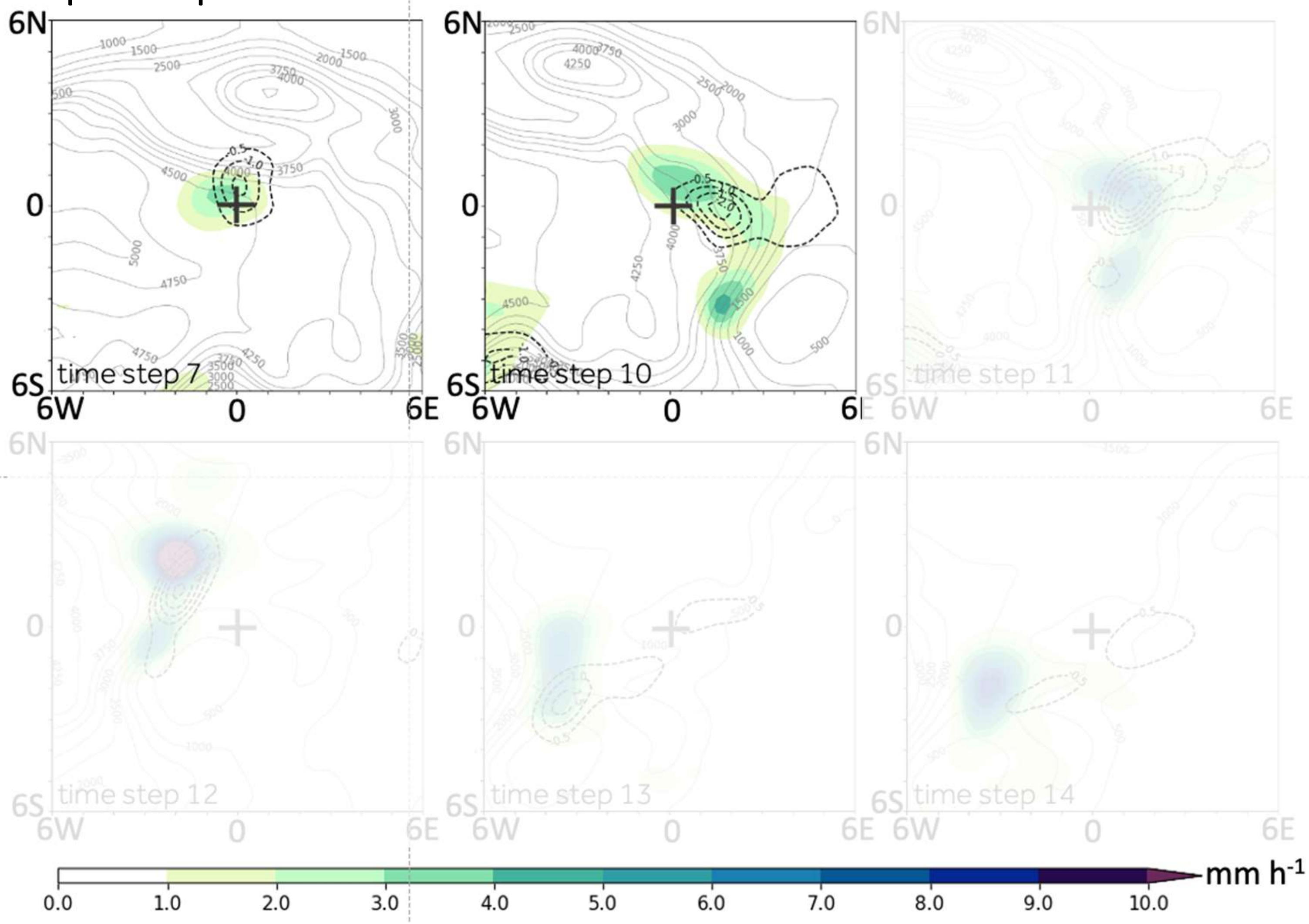
July 2008 TPV associated precipitation



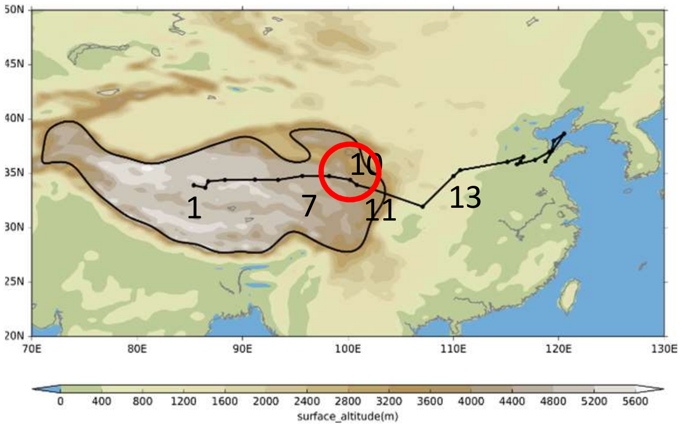
Colour shading: precipitation rate
Grey contours: orography
Dotted contours: updraft



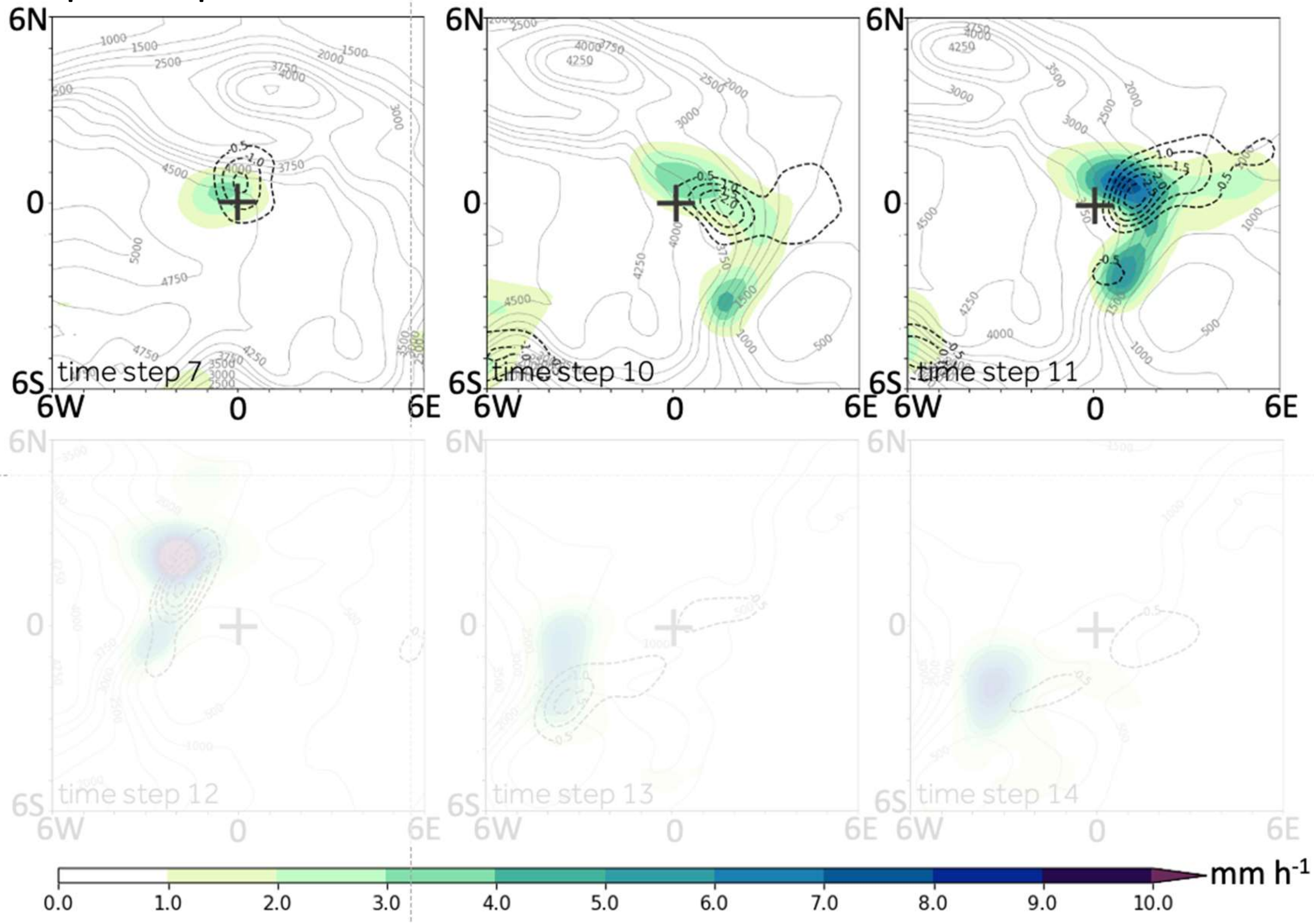
July 2008 TPV associated precipitation



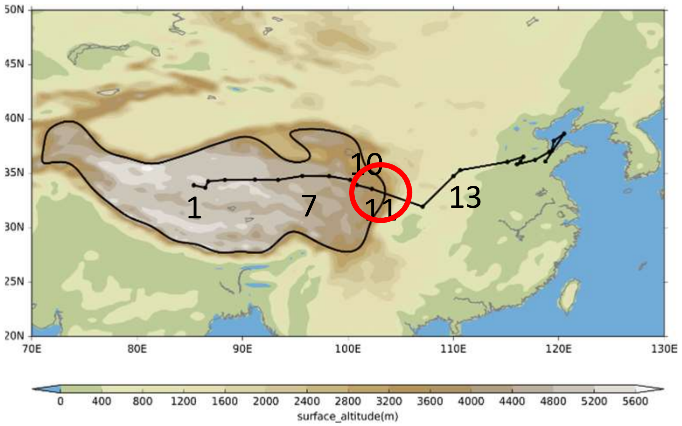
Colour shading: precipitation rate
Grey contours: orography
Dotted contours: updraft



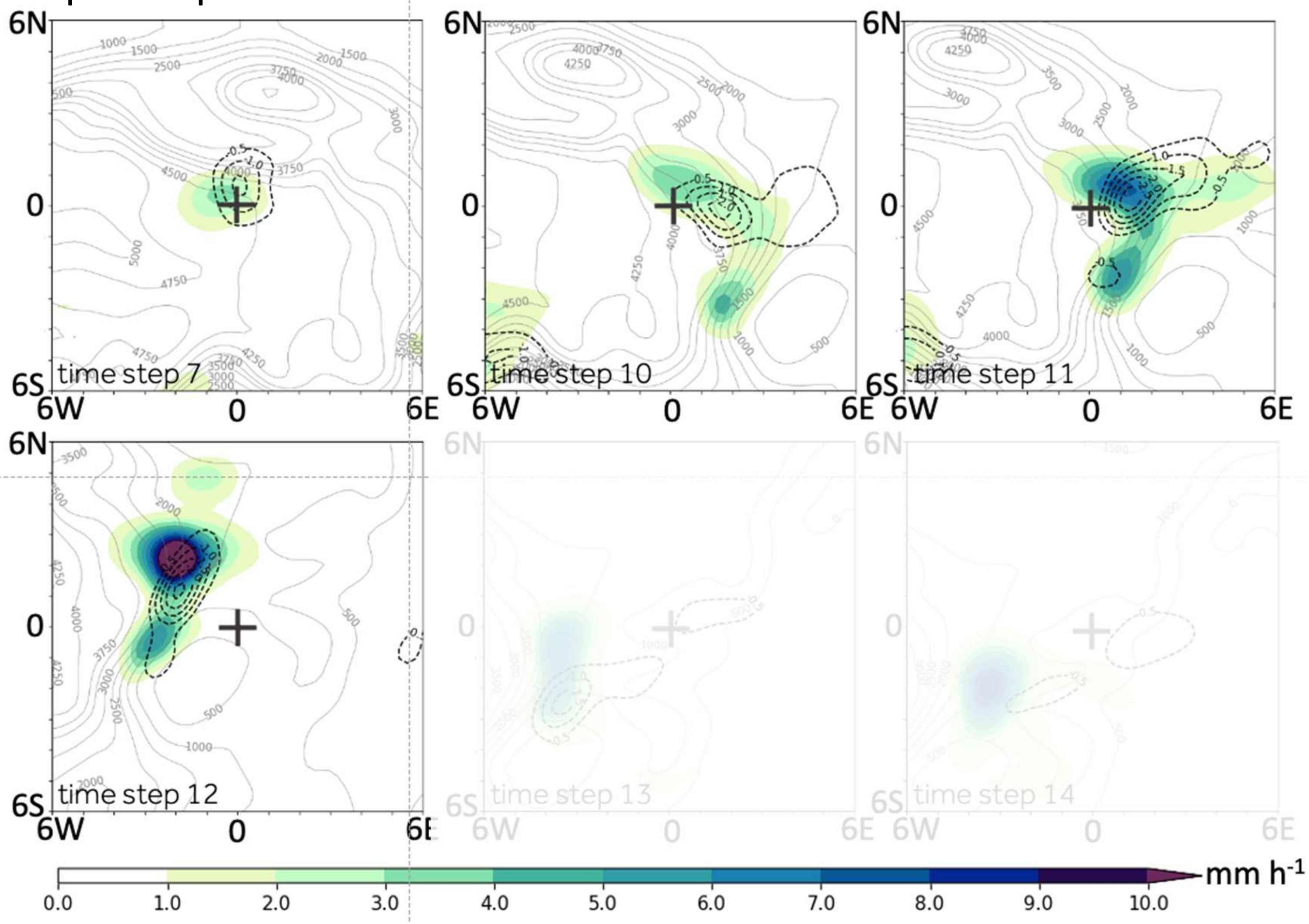
July 2008 TPV associated precipitation



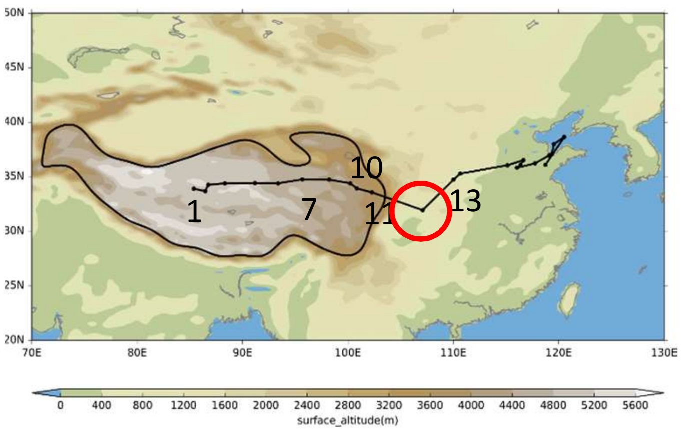
Colour shading: precipitation rate
Grey contours: orography
Dotted contours: updraft



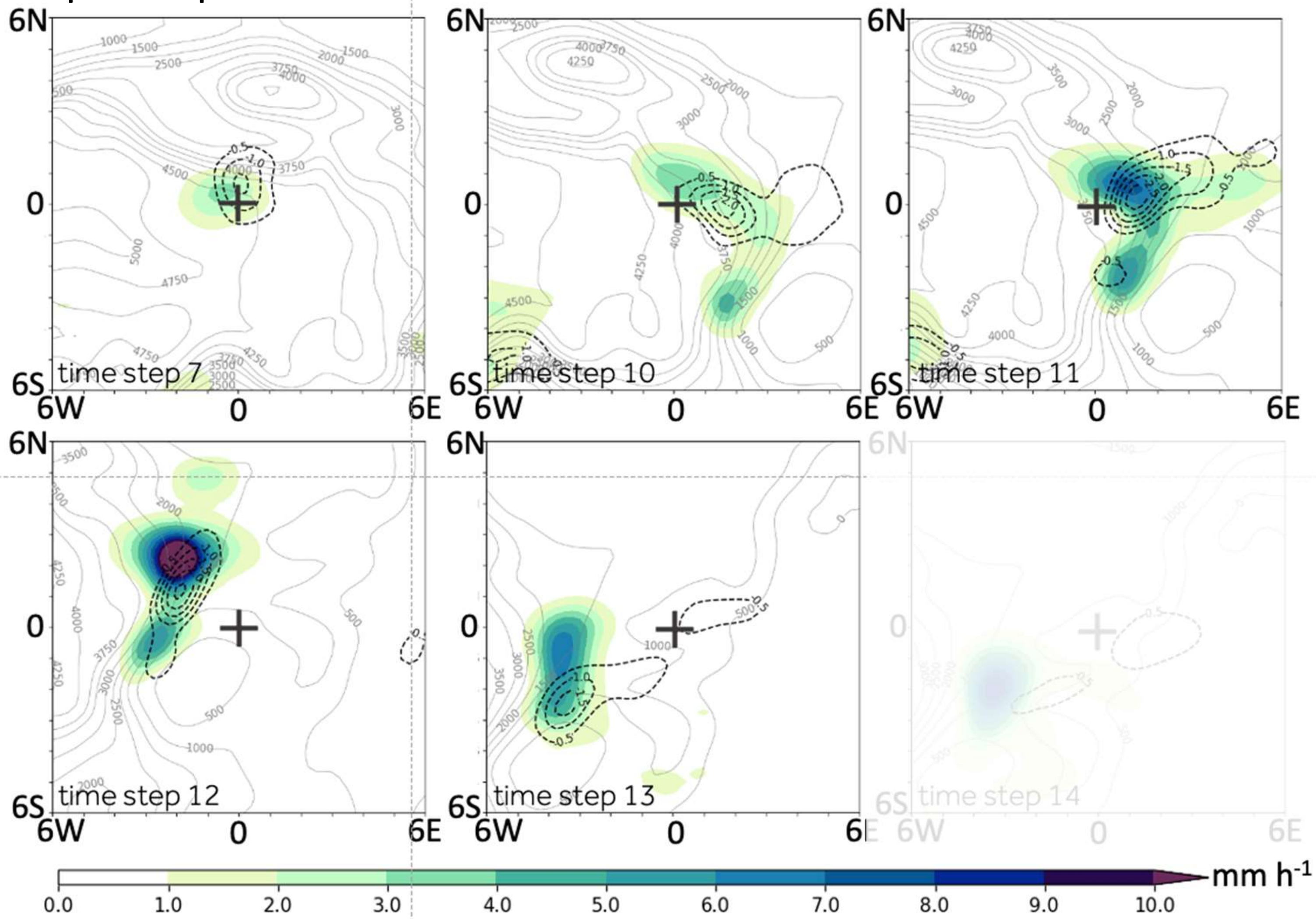
July 2008 TPV associated precipitation



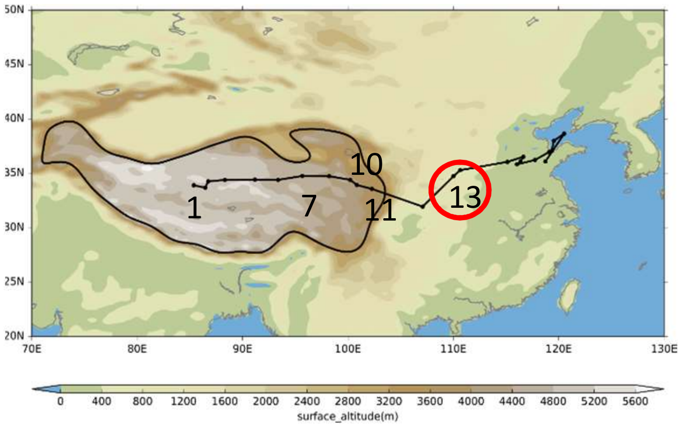
Colour shading: precipitation rate
Grey contours: orography
Dotted contours: updraft



July 2008 TPV associated precipitation

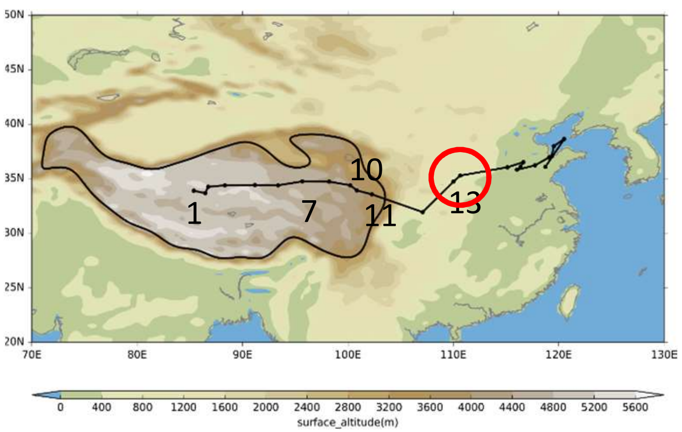


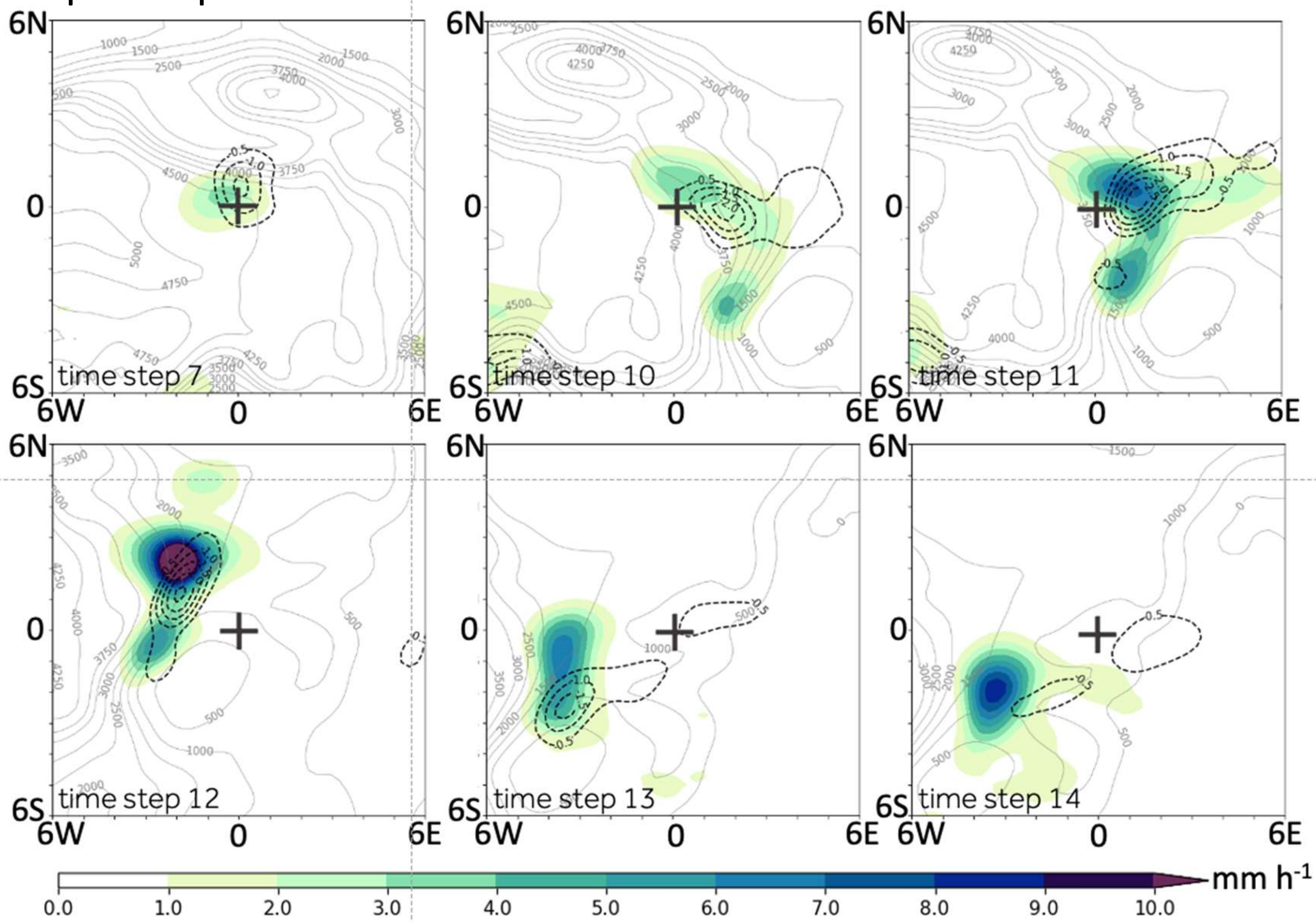
Colour shading: precipitation rate
Grey contours: orography
Dotted contours: updraft



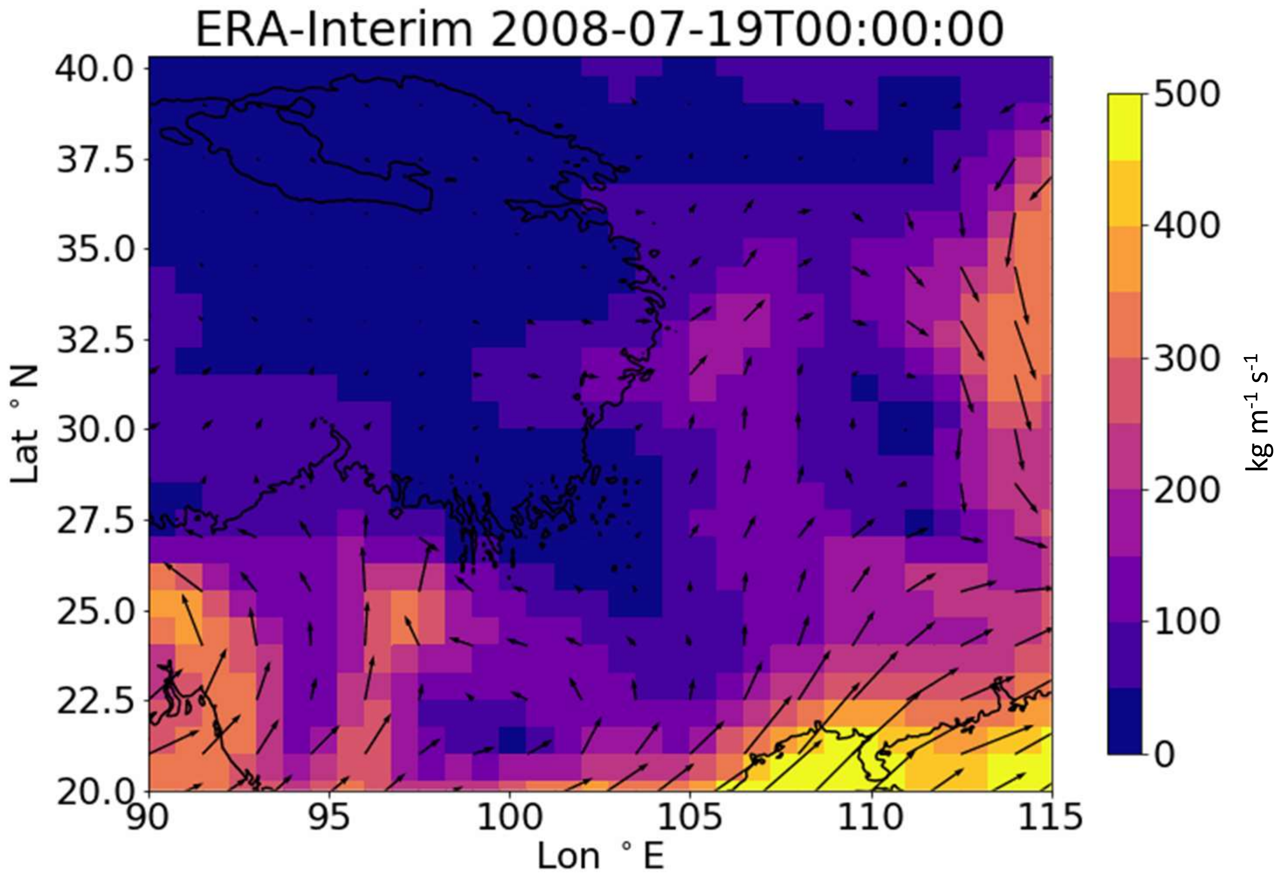
July 2008 TPV associated precipitation

Colour shading: precipitation rate
Grey contours: orography
Dotted contours: updraft

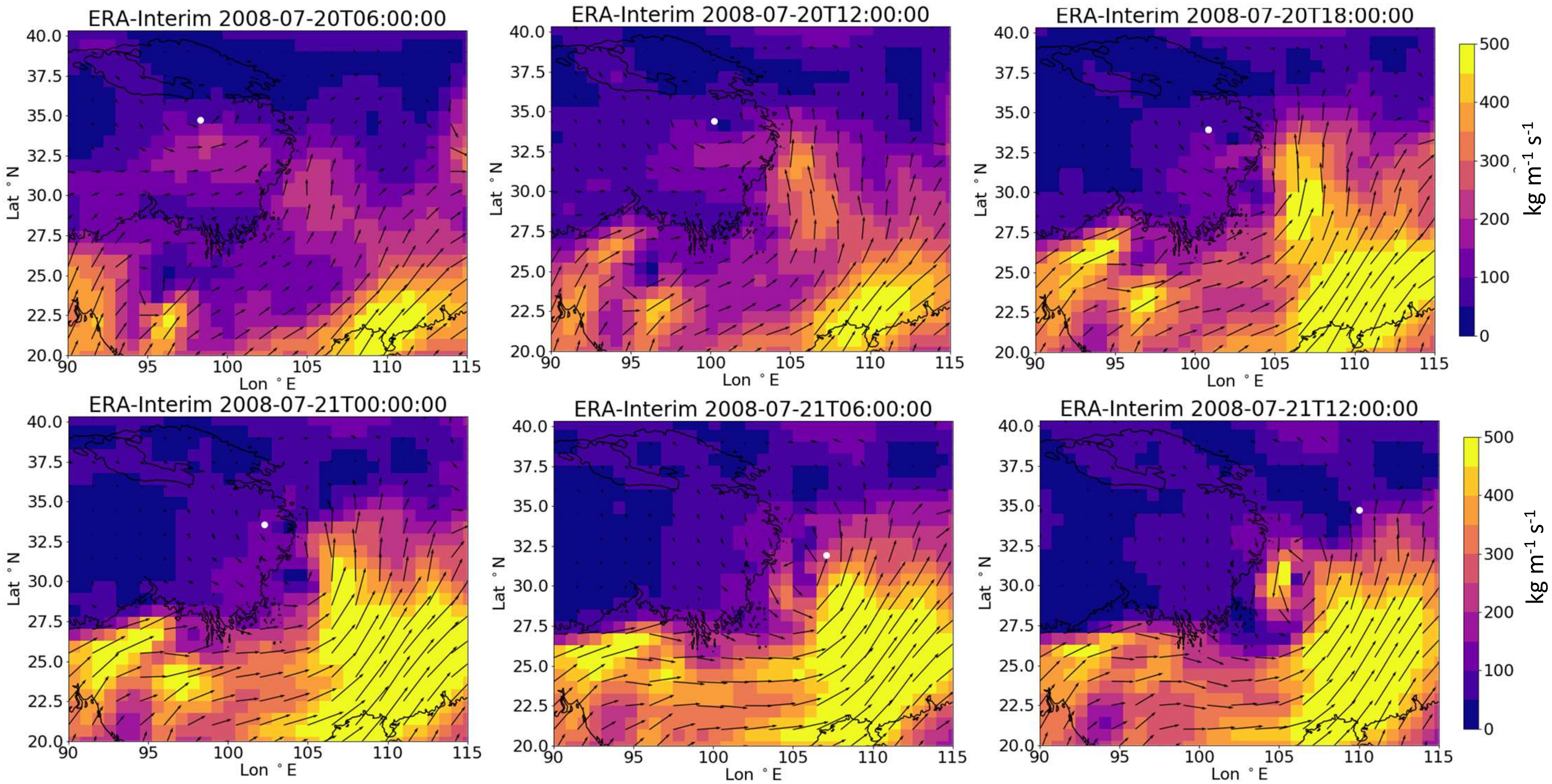




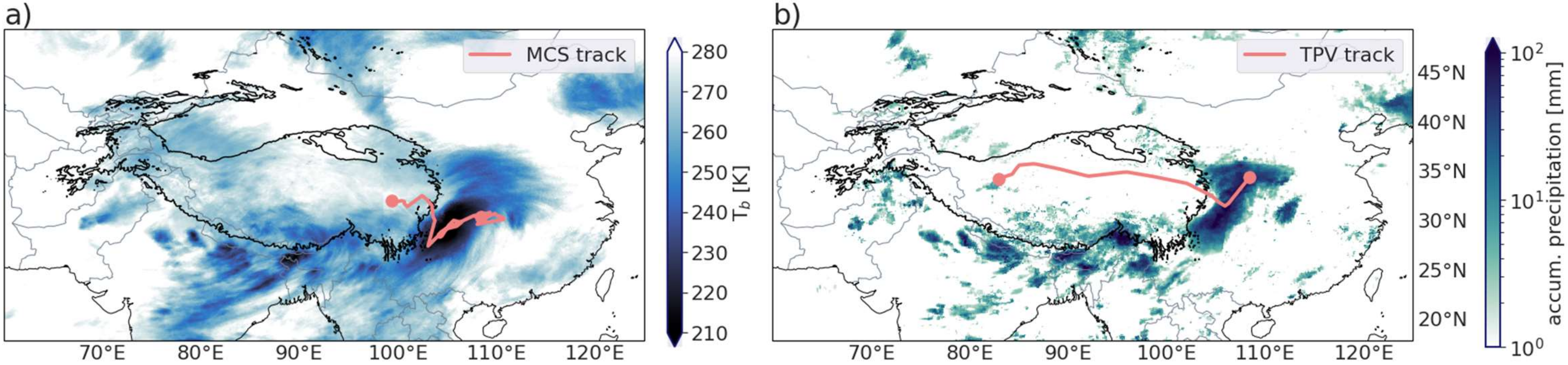
Moisture transport



Moisture transport



Mesoscale convective system (MCS) triggered by moving-off TPV



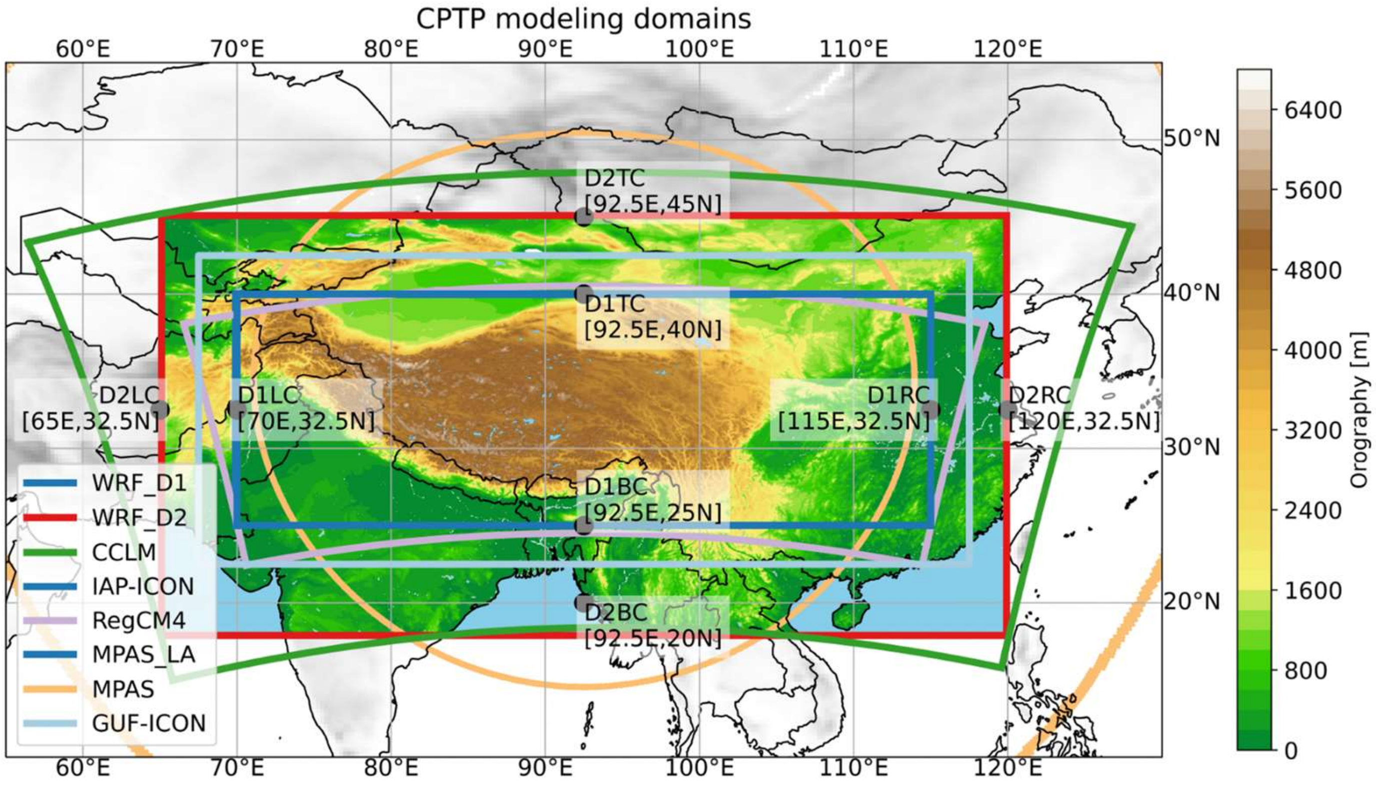
(a) Satellite retrieved mean brightness temperatures (K) and (b) accumulated precipitation (mm) from GPM IMERG during the 12 h with maximum rainfall and cloud shield extent (1600 UTC 20 Jul 2008–0400 UTC 21 Jul 2008).

Kukulies et al. 2023, Journal of Climate

Andreas Prein

The Convection-Permitting Third Pole (CPTP) Project

Advancing Hydroclimate Research over the Third Pole with Km-Scale Modeling



http://rcg.gvc.gu.se/cordex_fps_cptp/

Modeling Systems

- WRF (multi physics)
- MPAS (regional & global)
- COSMO-CLM (GPU version)
- ICON
- RegCM4

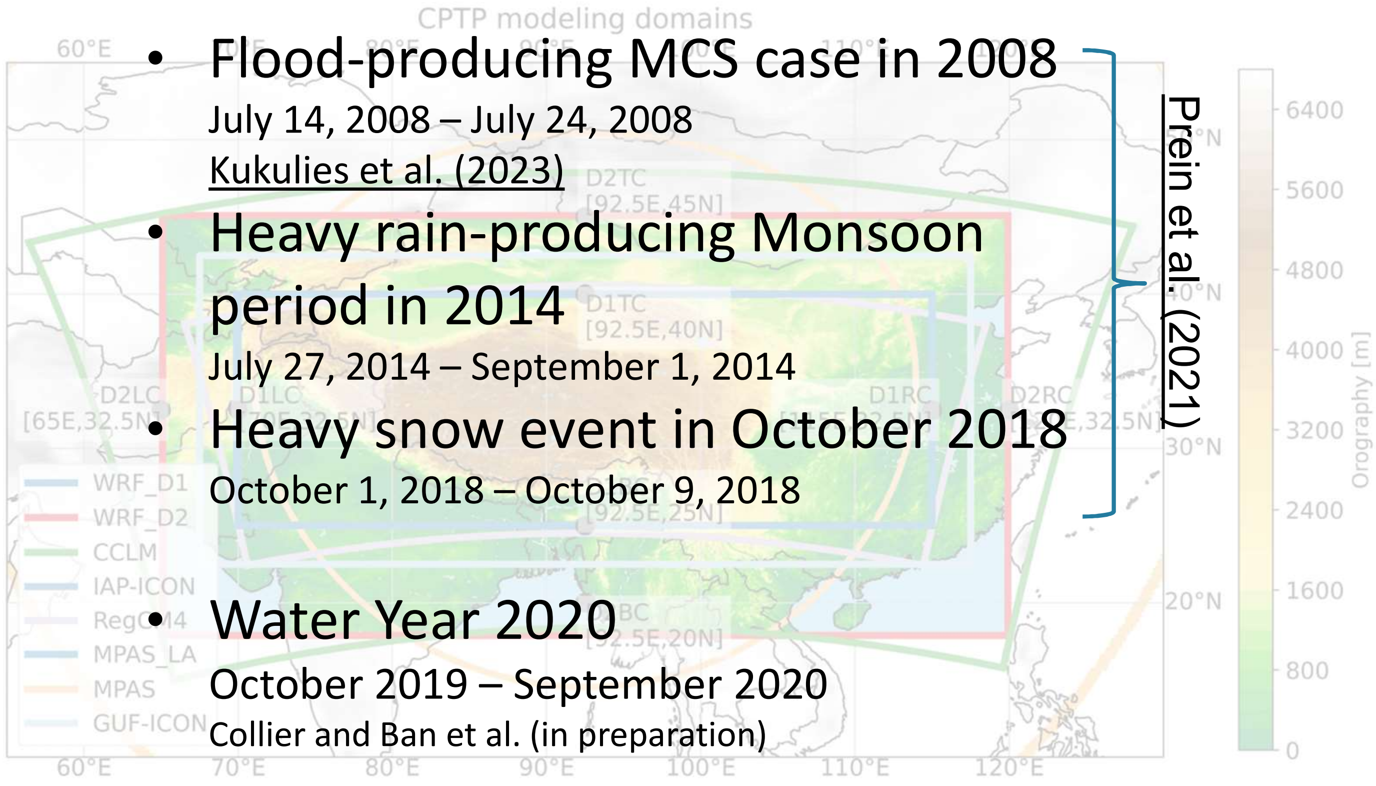
Downscaling ERA5 directly (for D2 domain) or with a 12 km intermediate nest (for D1 domain)

Prein et al. 2022, Climate Dynamics

Andreas Prein

The Convection-Permitting Third Pole (CPTP) Project

Advancing Hydroclimate Research over the Third Pole with Km-Scale Modeling



- Flood-producing MCS case in 2008
  July 14, 2008 – July 24, 2008
  Kukulies et al. (2023)
- Heavy rain-producing Monsoon period in 2014
  July 27, 2014 – September 1, 2014
- Heavy snow event in October 2018
  October 1, 2018 – October 9, 2018

Prein et al. (2021)

- Water Year 2020
  October 2019 – September 2020
  Collier and Ban et al. (in preparation)

http://rcg.gvc.gu.se/cordex_fps_cptp/

WCRP CORDEX FLAGSHIP PILOT STUDIES

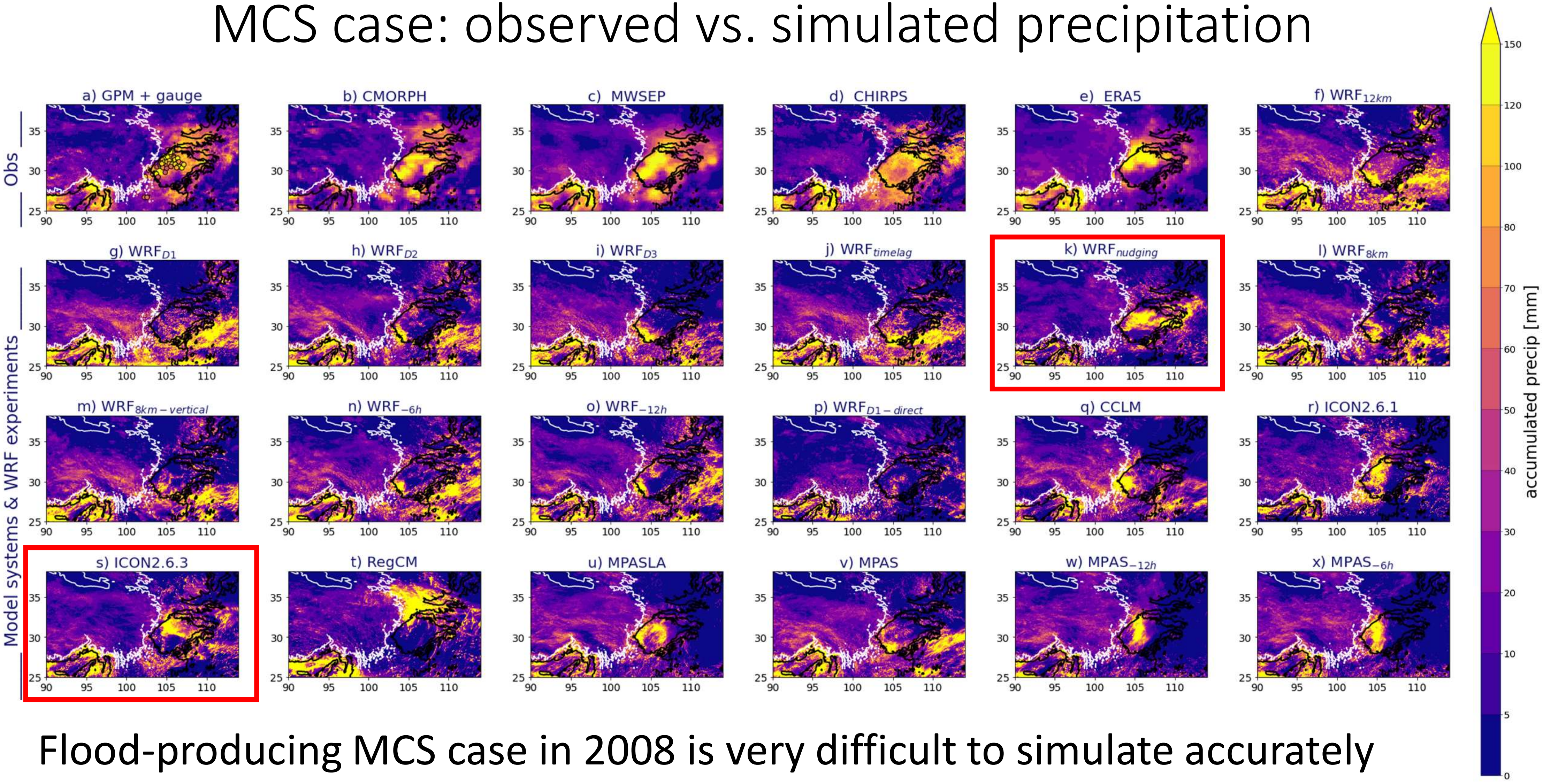
Modeling Systems

- WRF (multi physics)
- MPAS (regional & global)
- COSMO-CLM (GPU version)
- ICON
- RegCM4

Downscaling ERA5 directly (for D2 domain) or with a 12 km intermediate nest (for D1 domain)

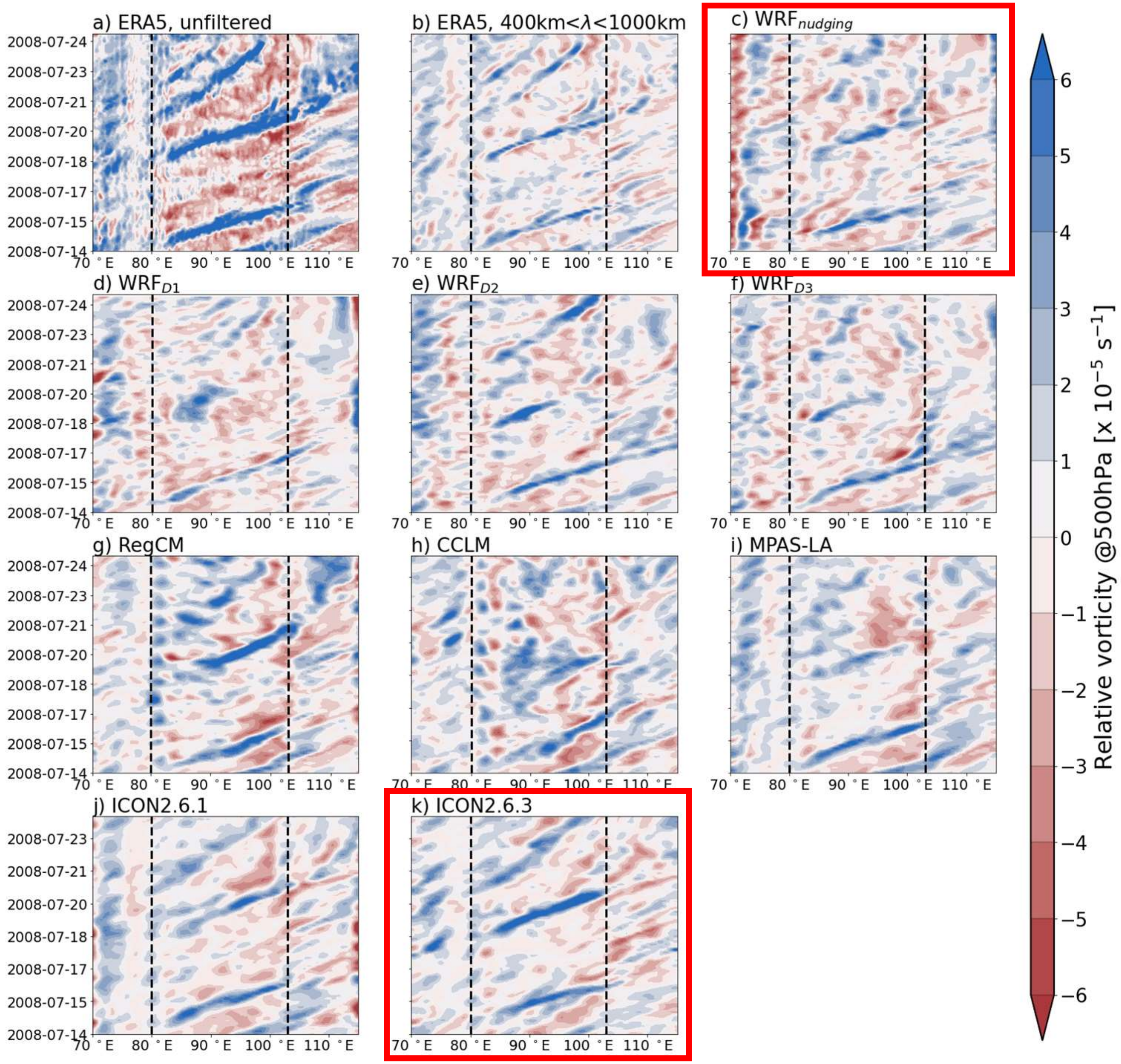
Prein et al. 2022, Climate Dynamics

MCS case: observed vs. simulated precipitation



Flood-producing MCS case in 2008 is very difficult to simulate accurately

Kukulies et al. 2023, Journal of Climate

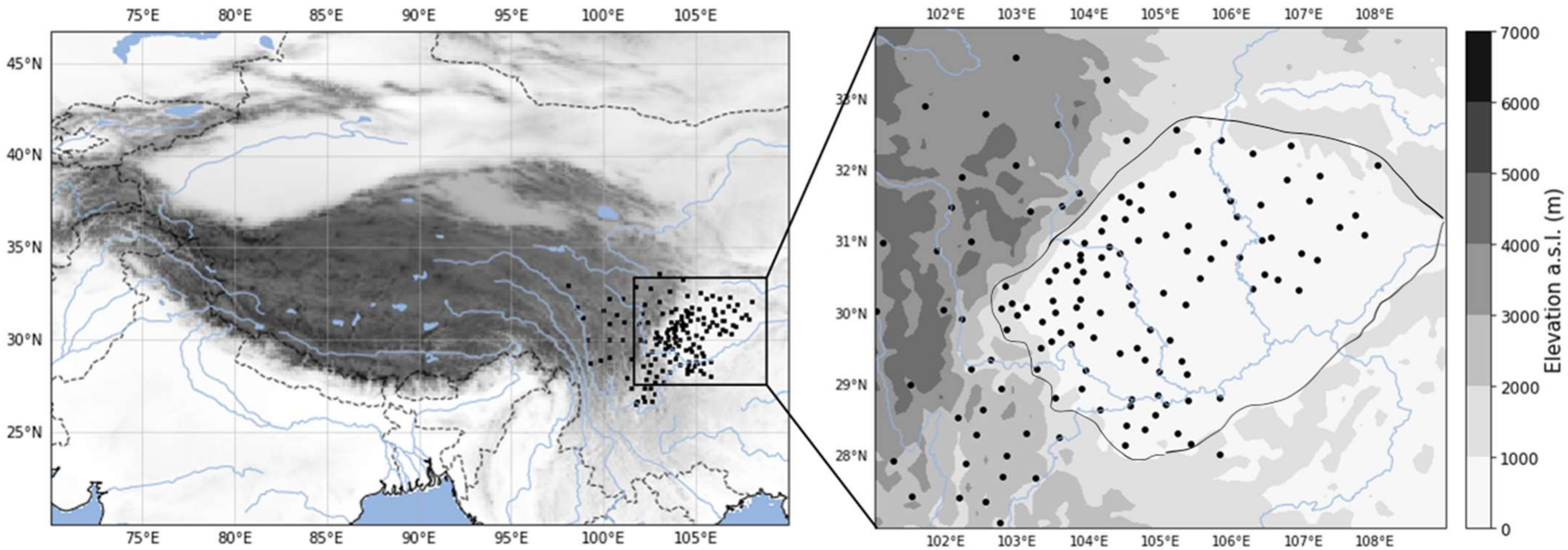


- The vortex associated with leeside MCS formation (blue streak starting from July 19) develops differently in the different modeling systems and is generally too weak in WRF simulations without spectral nudging.

- Results confirm that the TPV plays a key role for development of the MCS.

Kukulies et al. 2023, Journal of Climate

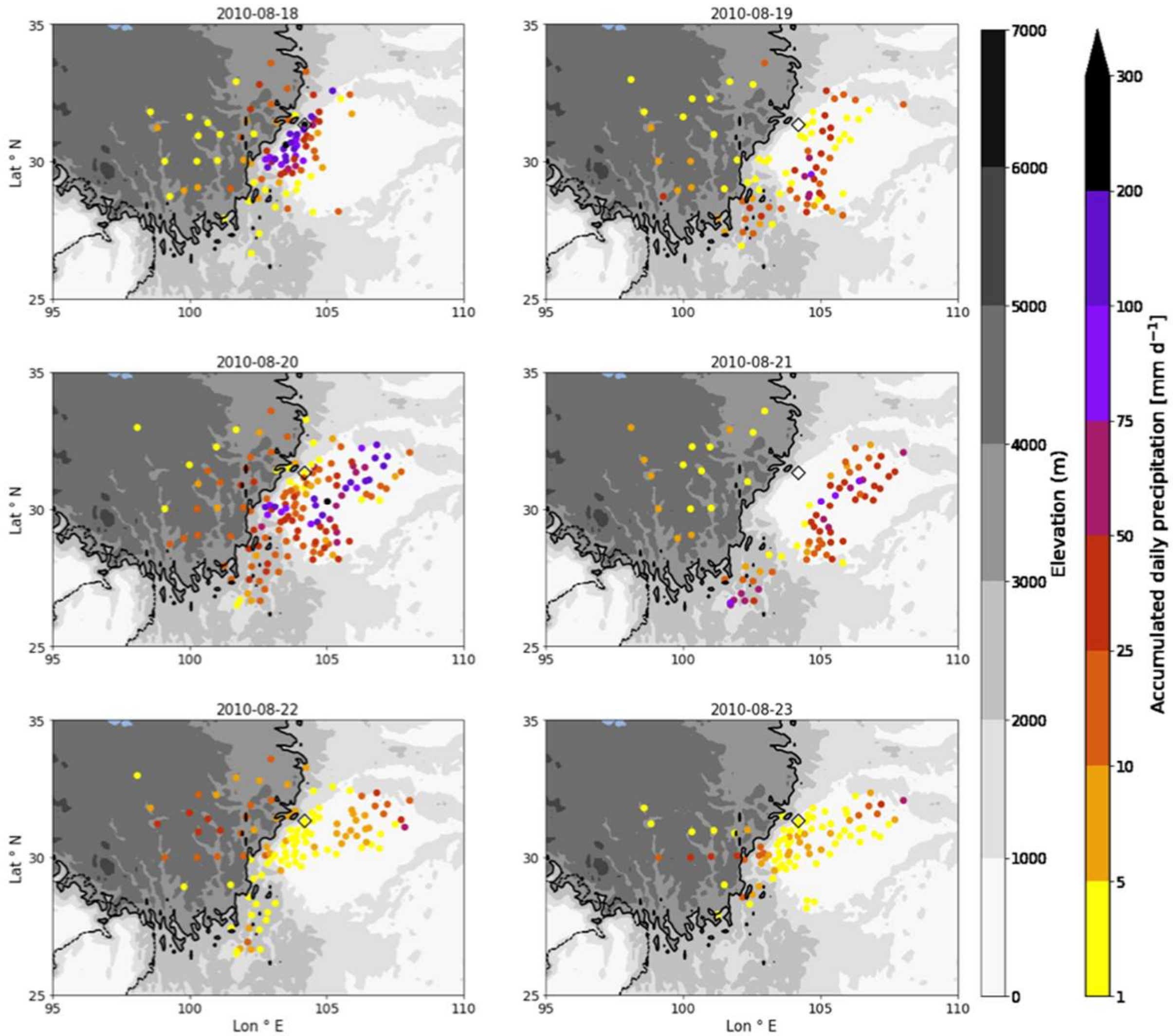
Extreme precipitation events in the Sichuan Basin based on in-situ observations (2000-2018)



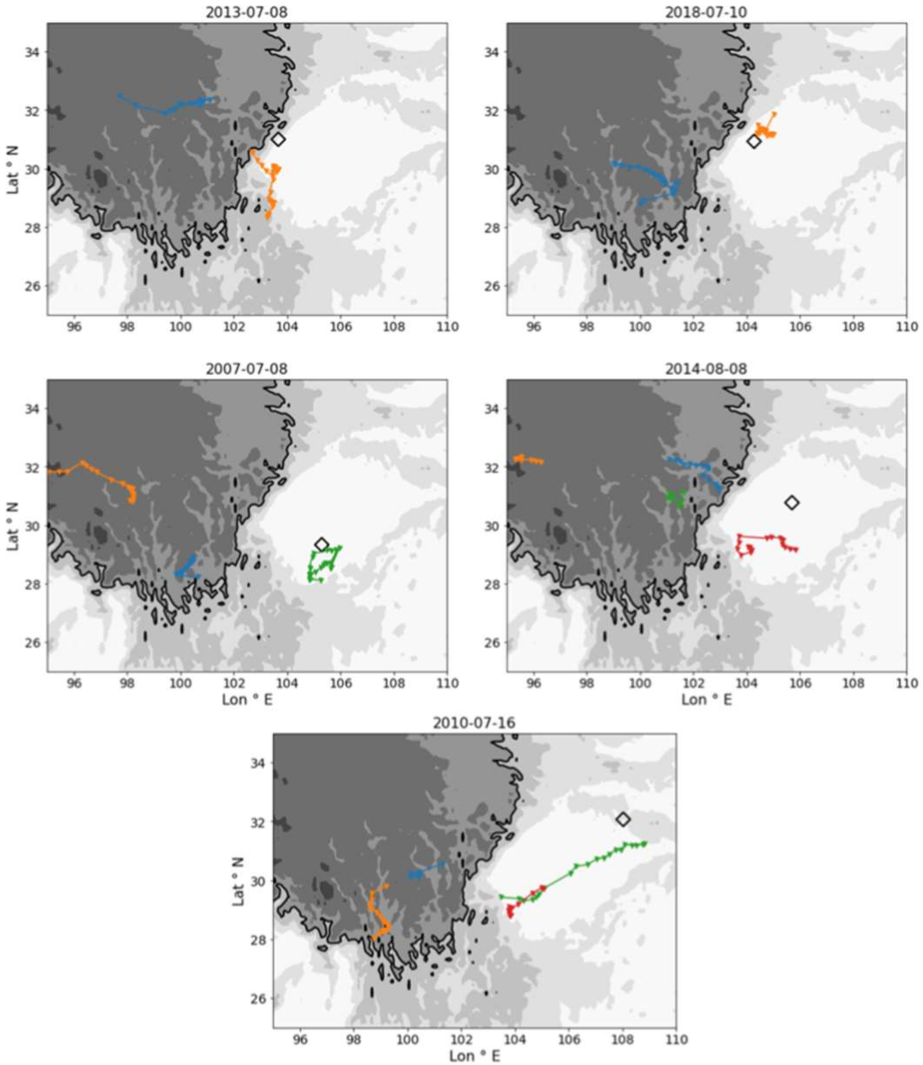
How often do extreme precipitation events in this region occur in connection to mesoscale weather systems?

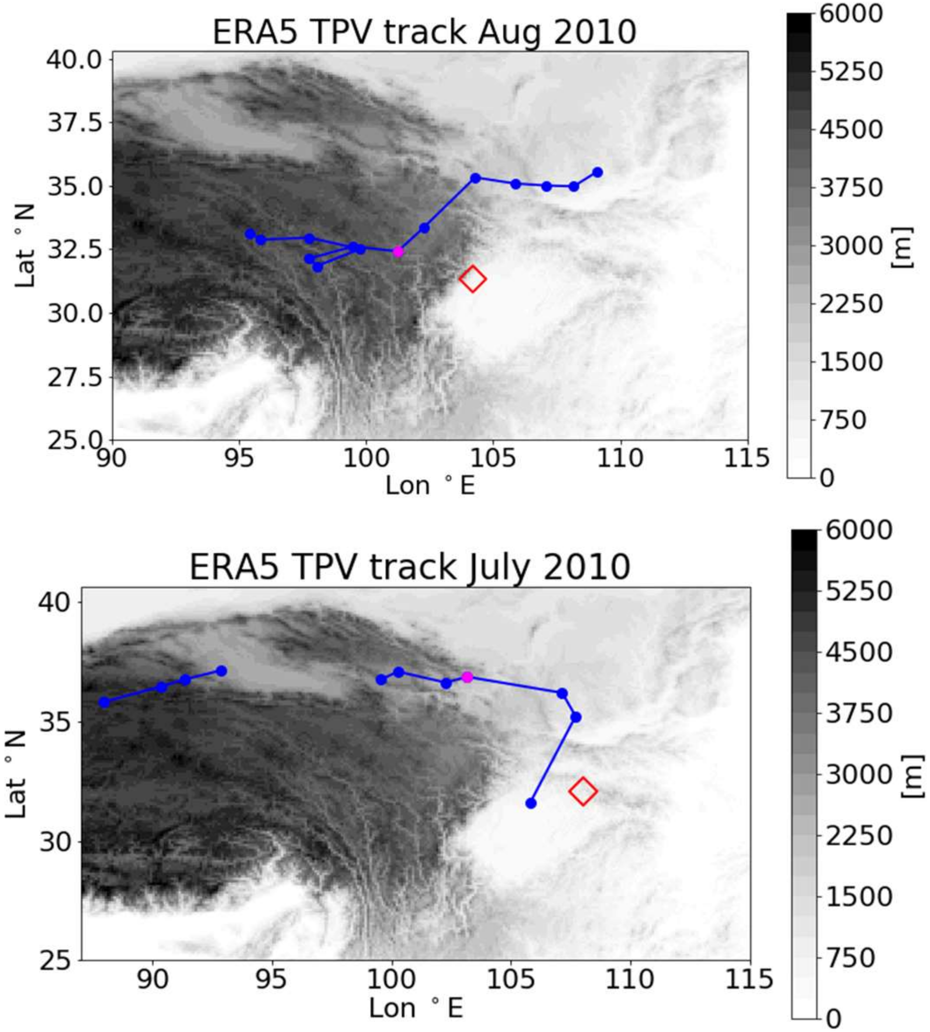
Extreme precipitation events based on in-situ observations (2000-2018)

N°	Station	Coordinates (long., lat.)	Date	Precipitation (mm d-1)	Elevation (m)
1	56188	103.67, 31.0	08-07-2013	423.8	698.5
2	56291	104.28, 30.93	10-07-2018	321.9	469.0
3	57507	105.3, 29.33	08-07-2007	298.7	373.4
4	56186	104.2, 31.33	18-08-2010	292.5	589.0
5	56297	104.15, 30.02	24-07-2010	284.5	436.5
6	57402	105.7, 30.77	07-06-2002	278.0	394.5
7	56196	104.73, 31.45	04-07-2017	266.7	522.7
8	57402	105.7, 30.77	08-08-2014	261.8	394.5
9	56665	101.85, 26.68	22-07-2007	261.7	1140.3
10	57237	108.03, 32.07	16-07-2010	255.8	674.0



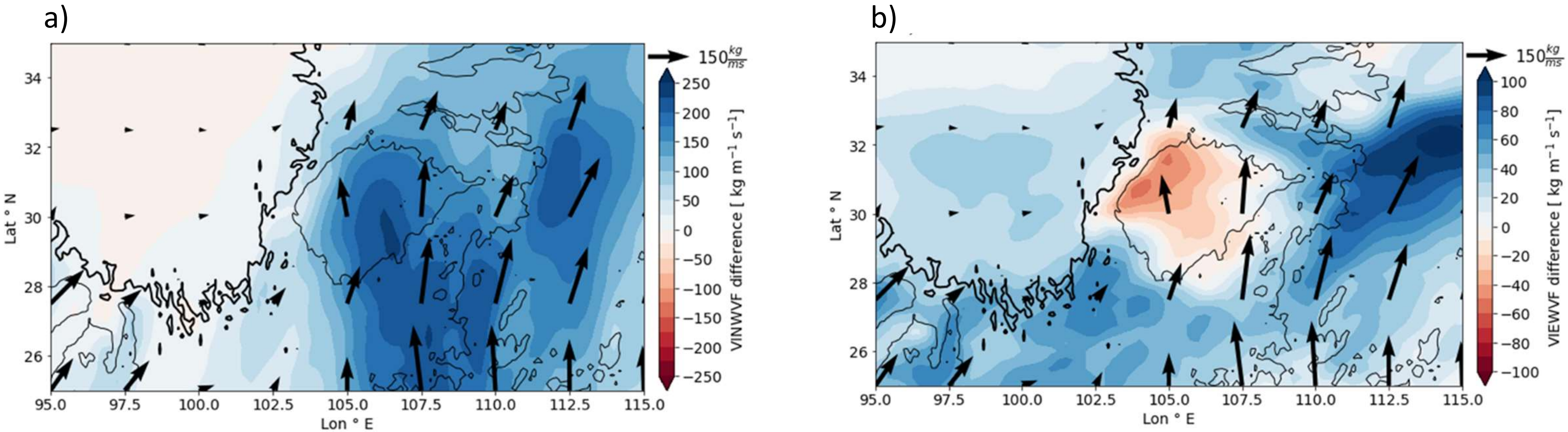
MCSs and TPVs associated with extreme precipitation events





More than half of the 10 most extreme precipitation events can be attributed to mesoscale weather systems.

Moisture transport July/August events in ERA5



Anomaly of vertically integrated northward (a) and eastward (b) water vapour flux (composite – climatology)

Stronger moisture transport into the Sichuan basin and towards the edge of the Tibetan Plateau during the extreme events than for the July/August climatology

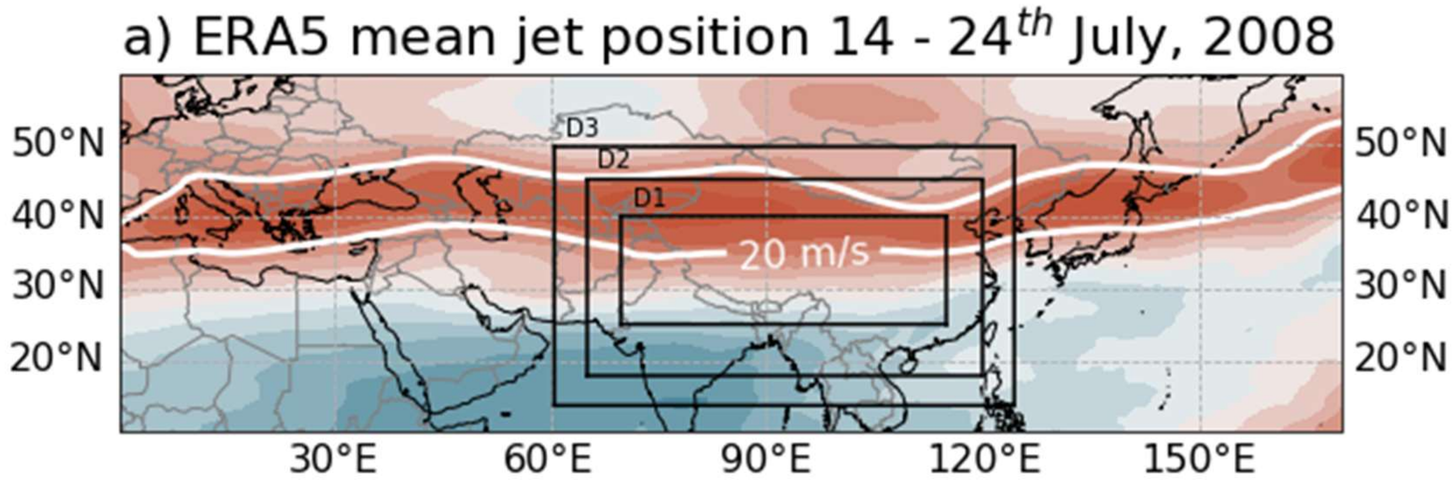
Connection to the jet stream

Extreme events

- **Jet stream further south during the June/July extreme events than for the climatology**

TPV/MCS case CPTP simulations

- **Larger domain sizes result in improved skill due to boundary interactions with the jet-Stream**



Kukulies et al. 2023

Position and strength of jet stream important for TPV development and path.

Key points

- TPV/MCS case July 2008 difficult to simulate accurately

→ only simulations that capture the TPV are able to simulate the flood-producing MCS

- More than half of the 10 most extreme precipitation events in the Sichuan Basin can be attributed to the occurrence of **mesoscale weather systems** (MCS, TPV, both)
- **Moisture transport** into the Sichuan facilitated by TPVs (mesoscale disturbances) & subtropical westerly jet further south during extreme events
- Position and strength of **jet** essential for **moving-off TPVs**
- Crucial to include the **jet** in the **domain** for convection-permitting simulations