

# Supplementary Information

## Reviewed papers (pg. 1 – 20)

## Hazard combinations (pg. 21 – 33)

Below is a list of the 366 peer reviewed papers that have been catalogued and reviewed, ordered A-Z by first author surname.

### A

Abatzoglou, J. T., Juang, C. S., Williams, A. P., Kolden, C. A., and Westerling, A. L.: Increasing synchronous fire danger in forests of the western United States, *Geophys. Res. Lett.*, 48, e2020GL091377, doi:10.1029/2020GL091377, 2021.

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Alaya, M. A. B., Zwiers, F. W., and Zhang, X.: A bivariate approach to estimating the probability of very extreme precipitation events, *Weather Clim. Extrem.*, 30, 100290, doi:10.1016/j.wace.2020.100290, 2020.

Alipour, A., Yarveysi, F., Moftakhari, H., Song, J. Y., and Moradkhani, H.: A multivariate scaling system is essential to characterize the tropical cyclones' risk, *Earth's Future*, 10, e2021EF002635, doi:10.1029/2021EF002635, 2022.

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Apel, H., Martínez Trepát, O., Hung, N. N., Chinh, D. T., Merz, B., and Dung, N. V.: Combined fluvial and pluvial urban flood hazard analysis: concept development and application to Can Tho city, Mekong Delta, Vietnam, *Nat. Hazards Earth Syst. Sci.*, 16, 941–961, doi:10.5194/nhess-16-941-2016, 2016.

Aksha, S. K., Resler, L. M., Juran, L., and Carstensen Jr, L. W.: A geospatial analysis of multi-hazard risk in Dharan, Nepal, *Geomatics Nat. Hazards Risk*, 11, 88–111, doi:10.1080/19475705.2019.1708438, 2020.

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Baldwin, J. W., Dessy, J. B., Vecchi, G. A., and Oppenheimer, M.: Temporally compound heat wave events and global warming: An emerging hazard, *Earth's Future*, 7, 411–427, doi:10.1029/2018EF001139, 2019.

Ballarin, A. S., Barros, G. L., Cabrera, M. C., and Wendland, E. C.: A copula-based drought assessment framework considering global simulation models, *J. Hydrol. Reg. Stud.*, 38, 100970, doi:10.1016/j.ejrh.2021.100970, 2021.

Ban, J., Lu, K., Wang, Q., and Li, T.: Climate change will amplify the inequitable exposure to compound heatwave and ozone pollution, *One Earth*, 5, 677–686, doi:10.1016/j.oneear.2022.05.002, 2022.

Baradaranshoraka, M., Pinelli, J. P., Gurley, K., Peng, X., and Zhao, M.: Hurricane wind versus storm surge damage in the context of a risk prediction model, *J. Struct. Eng.*, 143, 04017103, doi:10.1061/(ASCE)ST.1943-541X.0001790, 2017.

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Below is a list of hazard combinations catalogued and documented according to the Zscheischler et al. (2020) typology, organised alphabetically by typology type (Multivariate, Pre-conditioned, Spatially compounding, Temporally compounding). Under each hazard combination, a list of papers that explored the respective combination is provided.

### **Variables:**

Atmospheric pressure (Pressure); Burning Index (BI); Continuous Haines Index (CH); Convective available potential energy (CAPE); Dead fuel moisture (FM); Dew Point (DewPoint); Drought (Drought); Evaporation (Evap); Flood (Flood); Fire Weather Index (FWI); Forest Fire Danger Index (FFDI); Groundwater levels (Groundwater); Heatwaves (HW); High water acidity (HighAc); High precipitation (HighP); High pressure (HighPres); High relative humidity (HighRH); High solar radiation (HighRad); High sea level (HSL); High soil moisture (HighSM); High soil temperature (HighST); High temperatures during day (HighT); High temperatures during night (HighTnight); High wind (Wind); Landslide (Landslide); Lightning (lightning); Live fuel moisture (LFM); Low Chlorophyll (LowChl); Low precipitation (LowP); Low soil moisture (LowSM); Low soil temperature (LowST); Low solar radiation (LowRad); Low temperatures (LowT); Ozone (Ozone); Potential Evapotranspiration (PET); Precipitable water (PW); Precipitable water / extreme precipitation (PE); River discharge (RiverD); Sea surge (Surge); Sea surface temperature (SST); Snow (Snow); Standardised heat index (SHI); Standardised Precipitation Evapotranspiration Index (SPEI); Surface lift index (SLI); Surface runoff (Runoff); Tide level (Tide); Tropical cyclone (TC); Vapour pressure deficit (VPD); Wave height (Wave); Wildfire (Wildfire); Snowfall (Snow).

### **Multivariate events:**

- **CH & FFDI**

Pepler & Dowdy, 2018.

- **FFDI & Drought**

Ridder et al., 2020.

- **FFDI & HW**

Ridder et al., 2020.

- **FFDI & RiverD**

Ridder et al., 2020.

- **Flood & Wind**

English et al., 2017; Wang YF et al., 2021.

- **HighAc & LowOxy**

Gruber et al., 2021.

- **HighP & Hail**

Ridder et al., 2020.

- **HighP & Runoff**

Liu et al., 2018.

- **HighP & Surge**

Zhang et al., 2013; Zheng et al., 2014; van den Hurk et al., 2015; Wahl et al., 2015; Reed et al., 2016; Ai et al., 2018; Ridder et al., 2018; Wu et al., 2018; Bevacqua et al., 2019; Wu & Leonard, 2019; Gori et al., 2020a; Gori et al., 2020b; Ridder et al., 2020; Zhang et al., 2020; Bilskie et al., 2021; Fang et al., 2021; Khanam et al., 2021; Lai et al., 2021; Lai et al., 2021b; Santos et al., 2021; Tanim et al., 2021; Liu et al., 2022.

- **HighP & Tide**

Park & Lee, 2020.

- **HighP & Wave**

Catto & Dowdy, 2021.

- **HighP, HSL, Groundwater**

Jane et al., 2020; Rahimi et al., 2020.

- **HighP, RiverD, Surge, Wave**

Camus et al., 2021.

- **HighP, Wind, RiverD, HSL, HighSM**

Pietrafesa et al., 2019.

- **HighP, Wind, Wave**

Catto & Dowdy, 2021.

- **HighSM & FWI**

Sutanto et al., 2020.

- **HighT & Dew Point**

Whan et al., 2021.

- **HighT & Drought**

Ridder et al., 2020.

- **HighT & FWI**

Sutanto et al., 2020.

- **HighT & Hail**

Ridder et al., 2020.

- **HighT & HighP**

Zscheischler et al., 2014; Tencer et al., 2016; Zhou & Liu, 2018; Bonekamp et al., 2020; Singh & Najafi, 2020; Vogel et al., 2020; Weber et al., 2020; Aihaiti et al., 2020; Dabhi et al., 2021; Kapwata et al., 2021; Rulfova et al., 2021; Singh et al., 2021a; Wu et al., 2021d; Ye & Qian, 2021; Das et al., 2022; Kroll et al., 2022; Meng et al., 2022; Ning et al., 2022; Singh et al., 2022.

- **HighT & HighRH**

Zscheischler et al., 2019; Maung & Tustin, 2020; Garry et al., 2021; Villalobos-Herrera et al., 2021.

- **HighT & HW**

Ridder et al., 2020.

- **HighT & LowChl**

Le Grix et al., 2021.

- **HighT & LowP**

Zscheischler et al., 2014; Serinaldi, 2016; Sedlmeier et al., 2016; Kirono et al., 2017; Zscheischler & Seneviratne, 2017; Flach et al., 2018; Hao et al., 2018; Lu et al., 2018; Sedlmeier et al., 2018; Wang, et al., 2018; Zhou & Liu, 2018; Hao et al., 2019a; Feng et al., 2019; Hao et al., 2019b; Li et al., 2019; Manning et al., 2019; Mulder et al., 2019; Wu et al., 2019; Xu & Luo et al., 2019; Bezak & Mikos, 2020; De Luca et al., 2020b; Feng et al., 2020; Hao, Z et al., 2020; Hao, Y et al., 2020; Kong et al., 2020; Ribeiro et al., 2020a; Ribeiro et al., 2020b; Ridder et al., 2020; Singh & Najafi, 2020; Vogel et al., 2020; Wazneh et al., 2020; Weber et al., 2020; Wu et al., 2020a; Wu et al., 2020b; Zscheischler et al., 2020b; Aihaiti et al., 2021; Ballarin et al., 2021; Brunner et al., 2021; Collins, 2021; Dabhi et al., 2021; Feng et al., 2021b; Geirinhas et al., 2021; Hao et al., 2021a; hao et al., 2021b; Ionita & Nagavciuc, 2021; Lemus-Canovas et al., 2021; Li et al., 2021a; Li et al., 2021b; Liu & Zhou, 2021; Seo et al., 2021; Singh et al., 2021a; Szalinska et al., 2021; Tschumi et al., 2021; Vogel et al., 2021a; Wang WJ et al., 2021; Wu XY et al., 2021a; Wu XY et al., 2021b; Wu XY et al., 2021c; Wu et al., 2021d; Zscheischler & Lehner, 2021; Bevacqua et al., 2022; Chiang et al., 2022; Das et al., 2022; Kroll et al., 2022; Li et al., 2022; Li et al., 2022b; Liu et al., 2022; Libonati et al., 2022; Meng et al., 2022; Ridder et al., 2022a; Tang et al., 2022; Tootoonchi et al., 2022; Wu & Jiang et al., 2022; Zhang et al., 2022; Ridder et al., 2022b, Zhang et al., 2022b; Singh et al., 2022.

- **HighT & LowSM**

von Buttlar et al., 2018; Cheng et al., 2019; Sutanto et al., 2020; Ermitao et al., 2021; Hamed et al., 2021; Luan & Vico, 2021; Jiang et al., 2022; Zhang et al., 2022.

- **HighT & Ozone**

Herig et al., 2020; Jahn & Hertig, 2022; Zhang et al., 2020; Ban et al., 2022.

- **HighT, LowP & Pressure**

Rothlisberger & Martius, 2019; Gao et al., 2020.

- **HighT, LowP & VPD**

Vogel et al., 2021b; Gazol & Camarero, 2022.

- **HighT, LowP, LowSM**

Muthuvel & Mahesha, 2021; Guo et al., 2022; Chen et al., 2019; Mukherjee et al., 2020; Yu & Zhai, 2020; Yu & Zhai, 2020b; Wu et al., 2022.

- **HighT, RH & Wind**

Tavakol et al., 2020.

- **HSL & HighP**

Bengtsson, 2016; Grip et al., 2021; Sanuy et al., 2021; Naseri & Hummel, 2022.

- **HSL & RiverD**

Moftakhari et al., 2017; Ward et al., 2018; Ganguli & Merz, 2019; Ganguli & Merz, 2019b; Pasquier et al., 2019; Serafin et al., 2019; Munoz et al., 2020; Bevacqua et al., 2021a; Fan et al., 2021; Ghanbari et al., 2021.

- **HW & Drought**

Ridder et al., 2020.

- **HW & Hail**

Ridder et al., 2020.



- **HW & LowP**

Ridder et al., 2020.

- **LFM, Wind, SHI, FM, ERC, BI, VPD**

Khorshidi et al., 2020.

- **LowP & PET**

Manning et al., 2018.

- **LowSM & FWI**

Sutanto et al., 2020.

- **LowSM, HighT & FWI**

Sutanto et al., 2020.

- **LowT & HighP**

Zscheischler et al., 2014; Sedlmeier et al., 2016; Tencer et al., 2016; Zhou & Liu, 2018; Wazneh et al., 2020; De Luca et al., 2020b; Singh & Najafi, 2020; Dabhi et al., 2021; Wu et al., 2021d; Kroll et al., 2022.

- **LowT & LowP**

Zscheischler et al., 2014; Zhou & Liu, 2018; Singh & Najafi, 2020; Dabhi et al., 2021; Wu et al., 2021; Zhang, YQ et al., 2021b; Kroll et al., 2022; Li et al., 2022.

- **LowT & Snow**

D'Errico et al., 2022.

- **PW & PE**

Alaya et al., 2020.

- **RiverD & HighP**

Apel et al., 2016; Ridder et al., 2020.

- **RiverD & Surge**

Klerk et al., 2015; Bevacqua et al., 2017; Couasnon et al., 2018; Herdman et al., 2018; Hendry et al., 2019; Khanal et al., 2019; Couasnon et al., 2020; Eilander et al., 2020; Ganguli et al., 2020; Gori et al., 2020; Kirkpatrick & Olbert, 2020; Ridder et al., 2020; Dykstra & Dzwonkowski, 2021; Harrison et al., 2021; Robins et al., 2021; Camus et al., 2022; Jane et al., 2022.

- **RiverD & Wave**

Kupfer et al., 2022.

- **RiverD & Wind**

Ridder et al., 2020.

- **RiverD & HighT**

Turner et al., 2019.

- **Surge & Wave**

Petroliagkis, 2018; Sayol & Marcos, 2018; Lucio et al., 2020; Ridder et al., 2020; Housego et al., 2021.

- **Surge, Wave, HighP**

Bevacqua et al., 2020.

- **Surge, Wave, Tide, RiverD**

Fakhruddin et al., 2022; Sampurno et al., 2022; Qiu et al., 2022.

- **Surge/HSL, RiverD & HighP**

Gori et al., 2020; Paprotny et al., 2020; Tanir et al., 2021; Munoz et al., 2022.

- **TC and HSL**

Sheng et al., 2022.

- **VPD & LowSM**

Zhou et al., 2019a; Zhou et al., 2019.

- **Wave, Surge, HSL**

Anderson et al., 2019.

- **Wind & Drought**

Ridder et al., 2020.

- **Wind & Hail**

Ridder et al., 2020.

- **Wind & HighP**

Martius et al., 2016; Ye & Fang, 2018; Hillier & Dixon, 2020; Ridder et al., 2020; Catto & Dowdy, 2021; Henin et al., 2020; Song et al., 2020; Messmer & Simmonds, 2021; Owen et al., 2021a; Owen et al., 2021b; Ridder et al., 2021; Van de Walle et al., 2021; Vignotto et al., 2021; Zhang, YQ et al., 2021a; Zscheischler et al., 2021; Poulos et al., 2022; Ridder et al., 2022a; Ridder et al., 2022.

- **Wind & Surge**

Pei et al., 2014; Baradaranshoraka et al., 2017; Ridder et al., 2020; Snaiki et al., 2020; Lan et al., 2022.

- **Wind & Wave**

Catto & Dowdy, 2021.

- **Wind, Pressure, Runoff, Wave, HSL**

Parker et al., 2019.

- **Wind, Surge, HighP**

Alipour et al., 2022.

- **Wind, Wave, Surge**

Masoomi et al., 2019.

### **Pre-conditioned events:**

- **HighP on HighSM**

Poschlod et al., 2020; Camici et al., 2019; Khanal et al., 2019; Khatun et al., 2022.

- **HighT, HighRad, Evap, LowP- to LowSM**

Bevacqua et al., 2021.

- **HighT then High SST**

Dzwonkowski et al., 2021

- **HighT then LowT**

Pfleiderer et al., 2019.

- **Rain on Snow**

Pradhanang et al., 2013; Poschlod et al., 2020; Sezen et al., 2020; Shirzaei et al., 2021.

#### **Spatially compounding events:**

- **HighP & HighP**

De Michele et al., 2020; Bevacqua et al., 2021.

- **HighT and HighT**

Vogel et al., 2019.

#### **LowP and HighP**

De Luca et al., 2020a; De Michele et al, 2020.

- **LowP & LowP**

Liu et al., 2015; De Michele et al., 2020; Singh et al., 2021b; Zscheischler & Lehner, 2021.

- **RiverD & River D**

De Luca et al., 2017; Berghuijs et al., 2019; Deidda et al., 2021; Ma et al., 2021.

- **SPEI and SEPI**

Qi et al., 2022.

- **TC and TC**

Curtis et al., 2021.

#### **Temporally compounding events:**

- **Cyclone clusters (Cyclone-Cyclone)**

Bevacqua et al., 2020.

- **HighP then HighP**

Robbins, 2016; Shi et al., 2020; Vanelli et al., 2020; Bevacqua et al., 2021a; Tuel & Martius, 2021; Fish et al., 2022; Raymond et al., 2022.

- **HighP then HighT**

Chen et al., 2021; Liao Z et al., 2021.

- **HighP then Landslide**

Kirschbaum et al., 2020; Samodra et al., 2020.

- **HighP then LowP**

He & Sheffield et al., 2020; Shi et al., 2020.

- **HighT then HightnightT**

Chen et al., 2019; Zhang et al., 2020; Liao WL et al., 2021; Marengo et al., 2021; Rajkumar et al., 2021; Wang J et al., 2021; Wu, SJ et al., 2021a; Wang et al., 2022; Yang et al., 2022.

- **HighT then HighP**

Tencer et al., 2016; Weber et al., 2020; Wu SJ et al., 2021; You & Wang, 2021; Das et al., 2022.

- **HighT then HighT**

Baldwin et al., 2019; Raymond et al., 2022.

- **HighT then LowP**

Weber et al., 2020; Das et al., 2022.

- **LowP then HighP**

Shi et al., 2020; Vogel et al., 2020; Weber et al., 2020; Mishra et al., 2021; Das et al., 2022; Hoover et al., 2022; Raymond et al., 2022; Zamora-Reyes et al., 2022; Qiao et al., 2022.

- **LowP then HighT**

Pascoa et al., 2022.

- **LowP then LowP**

Shi et al., 2020.

- **TC then HighT**

Matthews et al., 2019; Zhao et al., 2021.

- **TC then TC (x6)**

Kuroda et al., 2021.

### **Combinations of typologies:**

#### **Preconditioned / Temporally compounding events:**

- **Drought then HighT**

Russo et al., 2019.

- **HighT then High SPEI then LowSM**

Zhang et al., 2019.

- **HighT then RiverD**

Gu et al., 2022.

- **HighST then LowST.**

Potopova et al., 2021.

- **LowP then LowSM**

Zhang et al., 2019; Vorobeuskii et al., 2022.

- **LowSM then HighP**

Trnka et al., 2016.

- **LowT then LowP**

Druckenbrod et al., 2019.

- **RiverD then HighT**

Gu et al., 2022.

- **Warm autumn (HighT), wet spring (HighT then HighP)**

Ben-Ari et al., 2018; Pfliegerer et al., 2021.

- **Wildfire then HighP**

Jacobs et al., 2016; Moftakhari & AghaKouchak, 2019; Kemter et al., 2021; Touma et al., 2022.

**Multivariate / Temporally compounding events:**

- **Drought and Drought**

Wu et al., 2022.

- **Flood then HighT & HighRH**

Zhang & Villarini, 2020.

- **HighT and HighRad then LowP and High SPEI**

Van den Wiel et al., 2021.

- **HighT & LowP then HighP**

Vogel et al., 2020.

- **HighP, Lightning, SLI, CAPE (sequence thunderstorms)**

Piper et al., 2016.

**Warm autumn (HighT), HighT & HighP spring**

Van der Velde., 2020.

**Pre-conditioned / Multivariate events:**

- **LowP then FFDI (HighT, RH, Wind)**

Richardson et al., 2022.

- **LowSM then HighT/LowP**

Matusick et al., 2018; Flach et al., 2021.

- **LowSM and HighT, LowRH, LowP, Pressure**

El Madany et al., 2020.

**Temporally / Pre-conditioned / Multivariate events:**

- **HighT & LowP consecutive years**

Bastos et al., 2020.

- **Hydrological drought and range of other conditions (HighP, HighT, RH, Wind, ET)**

Potopova et al., 2019.

- **Warm spring (HighT) then LowSM/HighT**

Bastos et al., 2020.

**Spatially compounding / Multivariate events:**

- **FWI and FWI**

Abatzoglou et al., 2020.



- **HighP & Wind -LowP & Wind**

Nugent et al., 2020.

- **HighT & LowP (global crops)**

Feng & Hao, 2020; Potopova et al., 2020; Bevacqua et al., 2021a; Feng et al., 2021a; Feng et al., 2021c; Lesk et al., 2021; He et al., 2021; He et al., 2022.