# The impact of future climate change on the water level of Lake Lesser Prespa: assessing the vulnerability of fish spawning grounds, and bird nesting- / foraging sites

**LIFE Prespa Waterbirds (LIFE15/NAT/GR/000936): Sep 2016-Sep 2021**

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ADAPT2CLIMA

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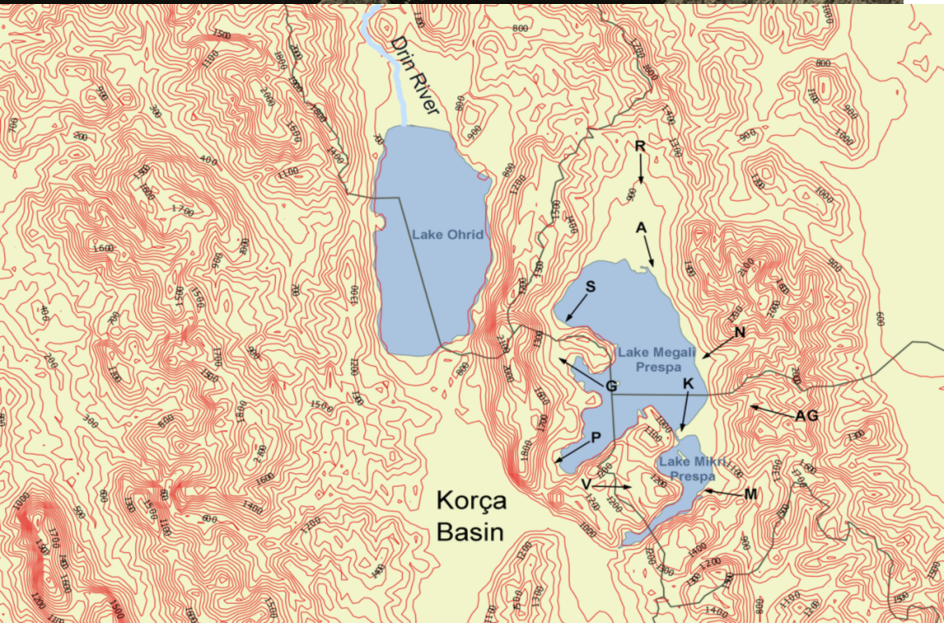
# Prespa Waterbirds: Objectives

To improve the conservation status of targeted bird species at Lesser Prespa Lake (a global biodiversity hotspot) - by implementing shoreline vegetation management actions.

**The main goal of NOA is to make management actions "climate proof"; that is, sustainable and effective under future climate change scenarios.**

Here we assess impacts of projected climate changes on lake shorelines and water levels.

# Background (1/3): Prespa Catchment

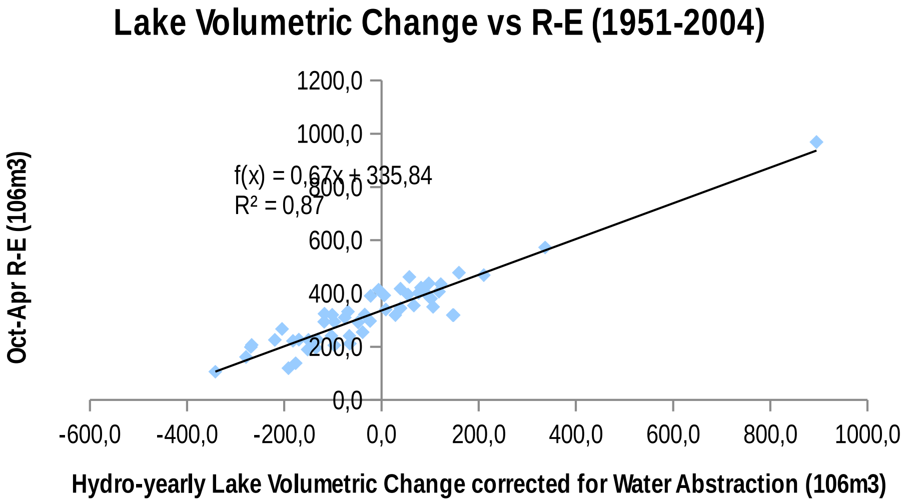

**Internally draining basin** (~1300$km^2$), surrounded by high mountains (2400m), location 40°51’53”N, 21°03’08”E.

**Occupied** by Lakes Lesser (850m) & Greater (844m) Prespa separated by sluice in istmus canal

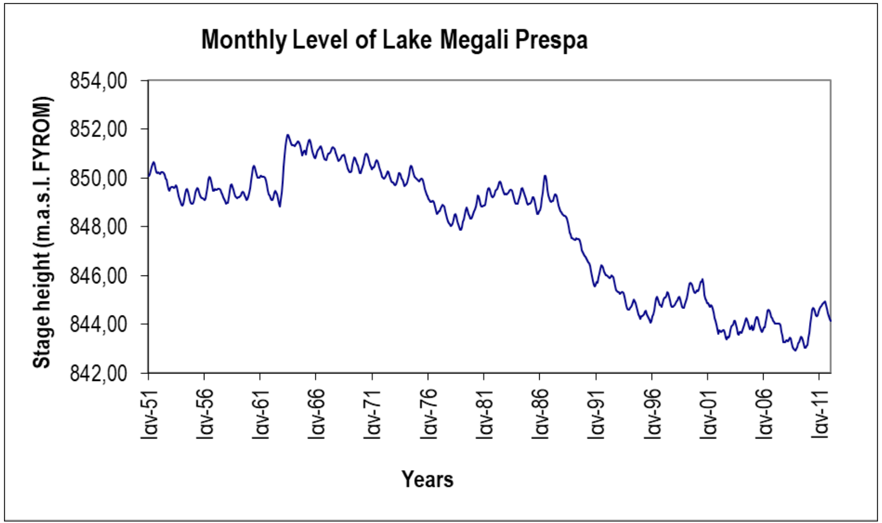
P 766mm and E 832mm (at lake level); **80% P falls Oct-Apr** (wet season).

**All fluvial & groundwater discharge into the lake is generated by catchment precipitation!**

# Background (2/3): Greater Prespa Lake




**Annual lake level is strongly related to wet season (Oct-Apr) precipitation.** Winter precipitation and snow cover are allied to the North Atlantic Oscillation winter index (negative: more precipitation)



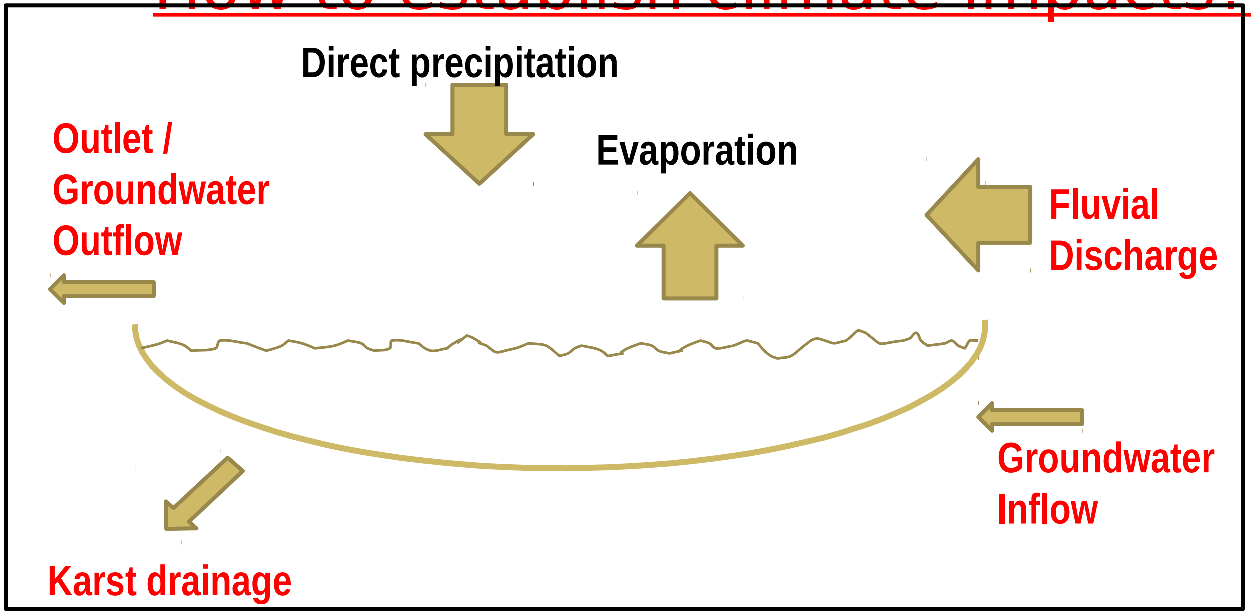

**The significant fall in lake level since 1987 is likely driven by climate changes, amplified by water abstraction.** Wet season rainfall and snowfall are decreasing, while droughts are increasing.

# Background (3/3): Lesser Prespa L

A **Lake Water Balance** for Lesser Prespa Lake could not be created: too many variables are unknown and water level is artificially controlled (no outflow record).

How to establish climate impacts?

To assess the impact of climate changes, specific lake level **thresholds** were linked to specific precipitation values (*next slide*)



# Methods (1/2): Study Approach

Observed data (hydro-climate, fire, lake and shoreline) were analysed to establish robust **base-line conditions** and climate-based **thresholds** for impact assessments associated with future climate projections.

Future climate projections were established, using

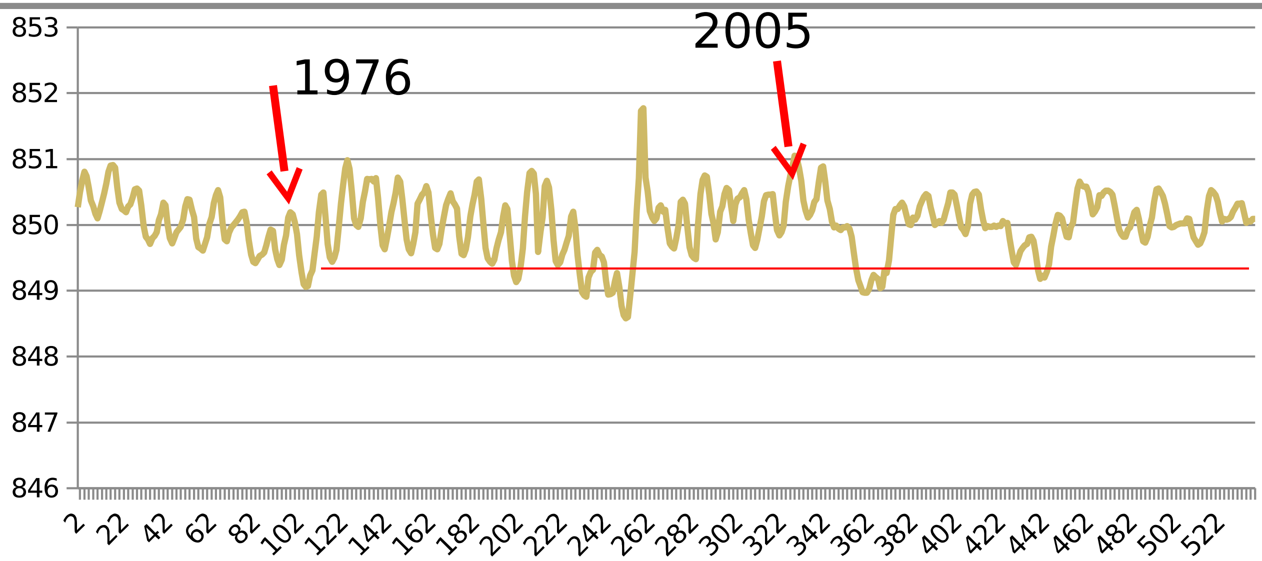
- Simulated daily output from a selected regional climate model developed within the CORDEX initiative.
- Model output of mean daily (maximum) temperature, daily total precipitation and evaporation were extracted.
- The "Canadian Fire Weather Index" (FWI) was used to assess fire risk

# Methods (2/2): Climate & Fire Projections

Climate-change projections cover the period 2071-2100.

- Regional Climate Model RCA4 of the Swedish Meteorological and Hydrological Institute (SMHI) driven by the Max Planck Institute for Meteorology global climate model MPI-ESM-LR
- Horizontal resolution of ~11km
- Two new IPCC future emissions scenarios : RCP4.5, RCP8.5
- Simulations carried out in the framework of EURO-CORDEX
- Future projections were adjusted with the delta-change method
- Non-parametric bootstrap confidence intervals (95th percentile) were employed to detect statistically significant climate changes

# Baseline (1/3): Lake Water Level




Lesser Prespa Lake level fluctuations in m above sea level (monthly; Feb 1969 – Dec 2016)

Most “natural” conditions: prior to 1976, when the Prespa Lakes were fully communicating and large-scale water storage / abstraction schemes were not yet operating. Seasonal fluctuations: 0.65-0.75 m. Long-term variability 851-849 m (since 1917: 852-847 m).

The sluice-system in the Koula outflow channel (since 2005; base at 849.6m) strongly dampens seasonal / long-term water level variability

# Baseline (2/3): Lake Level Threshc

## Four key lake level thresholds have been defined

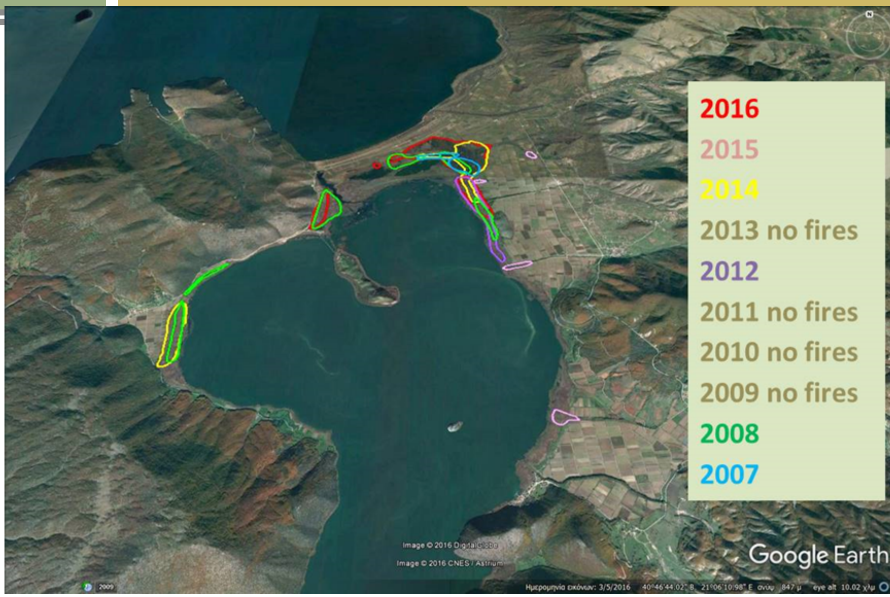
**Extreme lake level lowstands:** water level below 849.6m for >12 months (incl. at/below 849m for >4 months). Occurrence: **two subsequent wet seasons receive less than 370 mm** of precipitation each. Sluice: closed for up to 2 hydro-years.

**Significant lake level lowstands:** water levels are <850 m for 12 months (incl. below 849.6 m (sluice base) >4 months). Occurrence: wet season (Oct-Mar) precipitation is **below 370 mm** (20th perc.). Sluice: closed for the entire hydro-year.

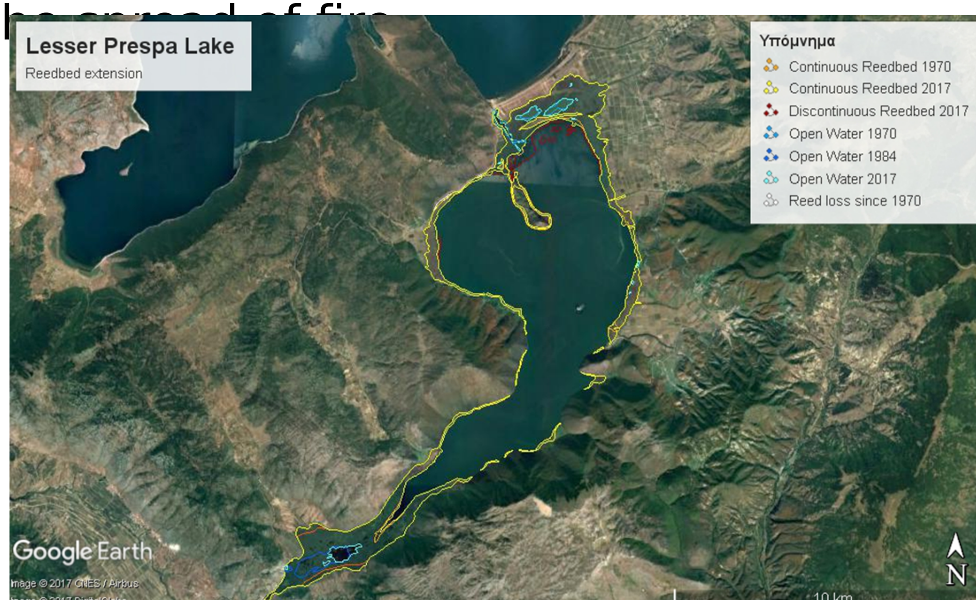
**Lake level lowstands:** water levels are <850 m for 7 months or more. Occurrence: wet season (Oct-Mar) precipitation is **below 415 mm** (40th perc.). Sluice: closed for the most of the hydro-year.

**Lake level highstands:** water levels are >850 m for the entire hydro-year. Occurrence: wet season precipitation is **above 560**

# Baseline (3/3): Fires & Reedbeds




Reedbed fires record (2007-2016). Too few data for statistical analyses: most fires occur in February and March (wet season, rising seasonal lake level). None started during a drought; low lake levels facilitate the spread of fire.




The width of the reedbeds fringing Lesser Prespa Lake has been remarkably stable over the period covered by the water level record (1969-

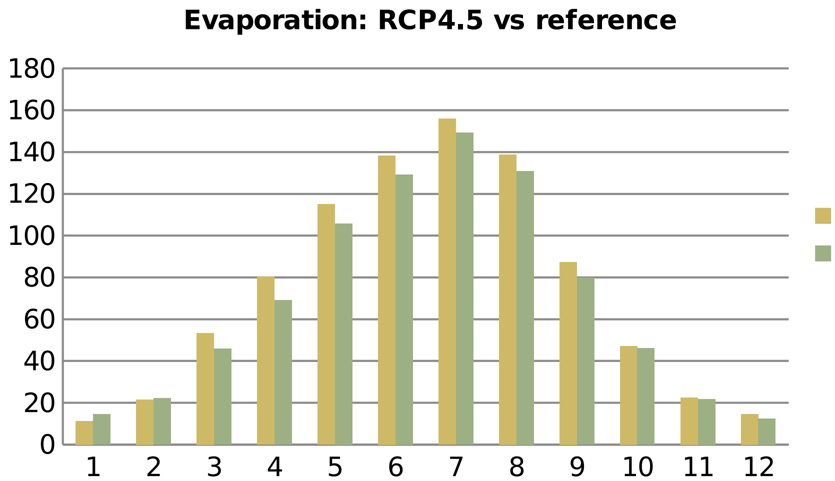
# Results (1/3): Future Precipitatio

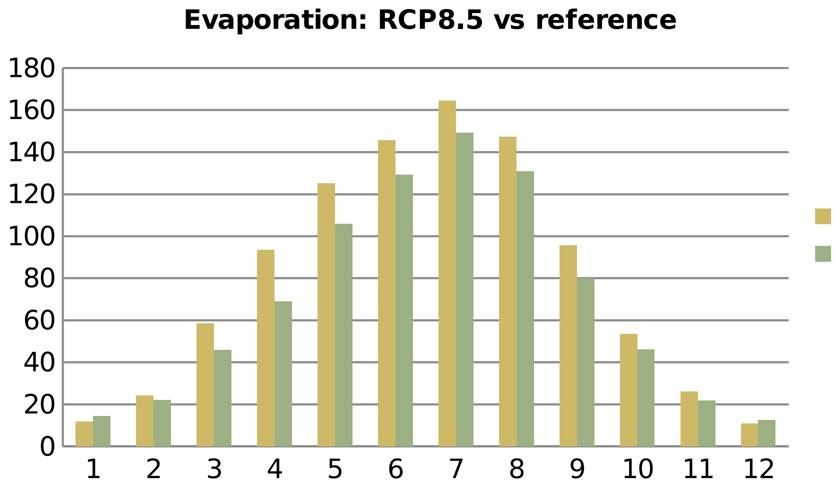
| | control | RCP45 | RCP85 |
|---|---|---|---|
| average | 724,16 | 672,19 | 637,77 |
| 5th | 517,70 | 437,16 | 409,49 |
| 10th | 574,60 | 491,15 | 464,02 |
| 15th | 589,90 | 505,55 | 481,25 |
| 20th | 622,20 | 552,02 | 530,70 |
| 25th | 633,80 | 589,58 | 562,51 |
| 75th | 818,60 | 770,11 | 735,88 |
| 80th | 825,20 | 791,13 | 744,27 |
| 85th | 841,40 | 834,46 | 767,03 |
| 90th | 868,00 | 858,20 | 804,44 |
| 95th | 972,10 | 910,25 | 853,35 |

Precipitation (mm) averages and percentiles for the reference period (1971-2000) and RCP4.5 / 8.5 scenarios (2071-2100)

- Decrease in hydro-annual precipitation is only significant under RCP 8.5
- Dry season precipitation only decreases significantly under RCP 8.5
- Average wet-season precipitation and seasonality of the precipitation-regime do not significantly change by 2100
- Precipitation decreases across

# Results (2/3): Future Evaporation



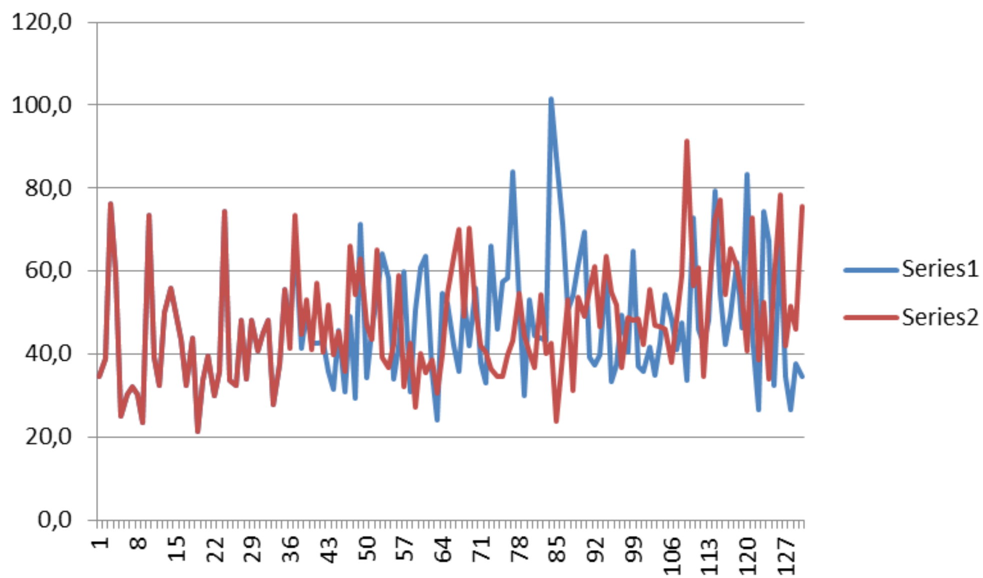

- Projected increases in annual evaporation are statistically significant under both scenarios
- **Annual open water surface** evaporation from the lake increases by 60 mm (7%; RCP4.5) to 129 mm (14%; RCP8.5) at the end of this century

# Results (3/3): Wet-/Dry Periods

The nature of future wet- and dry periods is changing:

Years characterized as **wet** (hydro-annual P >75$^{th}$ percentile) and as **dry** (hydro-annual P <25$^{th}$ percentile) receive statistically significantly less rainfall under RCP4.5/8.5. **For wet years this reduction is larger than for dry years**.

The **length of dry spel**
increases under both futu




Maximum dry spell length (no days: P<1mm): RCP 4.5 (series 1) and RCP8.5 (series 2) for 1971-2100.
**Statistically significant increase (large variability)**

# Impacts (1/4): Lake Level (I)

PRESPA WATERBIRDS

NATURA 2000

Years with very low water levels and no outflow through the Koula channel will increase

**Significant lake level lowstands: increasing frequency.**

Wet season (Oct-Mar) precipitation **below 370 mm** will increase from the 20$^{th}$ perc. to the **25$^{th}$ perc. in the future**. Sluice: closed entire hydro-year.

**Lake level lowstands: increasing frequency.**

Wet season (Oct-Mar) precipitation **below 415 mm** will increase from the 40$^{th}$ perc. to the **45$^{th}$ perc**. **in the future**. Sluice: closed most of the hydro-year.

**Lake level highstands: decreasing frequency.**

Wet season precipitation **above 560 mm** will decrease from the 90$^{th}$ perc. to the **95$^{th}$ perc. in the future**. Sluice: open entire hydro-year.

# Impacts (2/4): Lake Level (II)

The increase in evaporation under scenarios RCP4.5/8.5 may decrease seasonal peak lake levels in the order of 0.05 m and 0.13 m, respectively.

There are several uncertainties, all of which **amplify the negative impacts**:

[1] the decrease in dry-season precipitation (depressing summer-autumn lake level);

[2] extra water abstraction due to higher temperatures (depressing spring-summer lake level);

[3] less snow-melt induced runoff (decreasing seasonal lake level peaks).

# Impacts (3/4): Lake Shoreline

Shoreline fluctuations are expected to be approximately similar to the reference period.

Such long-term stabilization of shorelines is **unprecedented** in the observational record.

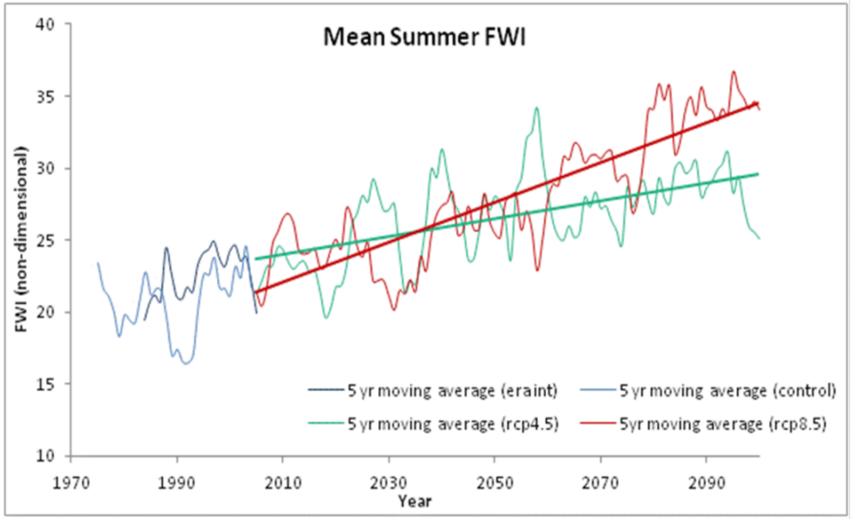
The sluice will be entirely closed for at least half of the future period, while it will be fully open for only two years.

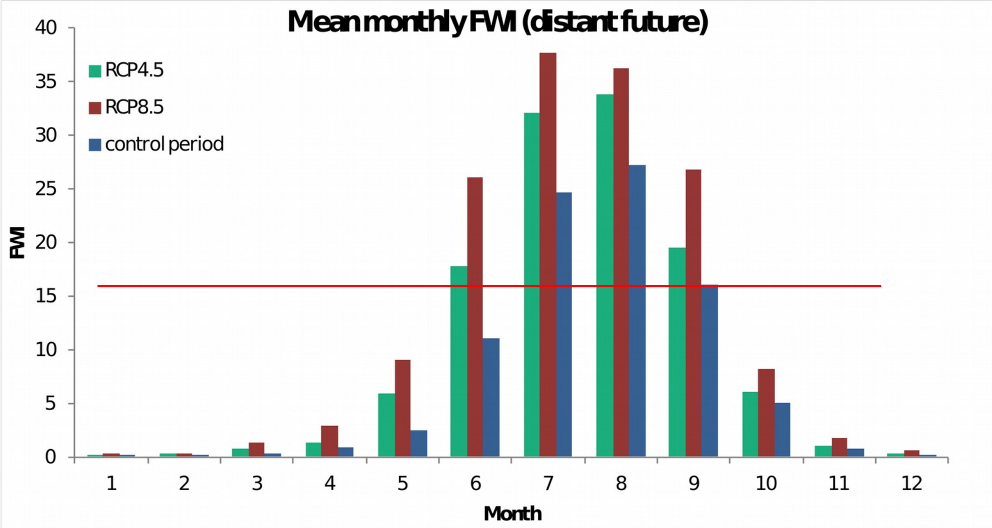
This implies that **seasonal water level fluctuations** will be strongly **reduced** and seasonal peak levels will be earlier in season (March-April), due to sluice operation.

*This will negatively affect bird foraging and fish spawning (reduced wet meadow flooding – reedbed invasion of wet meadows)*

# Impacts (4/4): Fire Conditions

In the future climate, more days with moderate and high fire risk are expected and the fire risk season expands into June and September. These changes are more pronounced under the RCP 8.5 scenario towards the end of the century (2071-2100).




However, late winter / early spring reedbed fire frequency is likely not affected

# Conclusions (1/2)

Seasonal and multi-annual lake level variations will likely greatly decrease as the sluices will be closed for long periods of time. There is no significant flow between the lakes and thus limited fluxing out of pollutants/nutrients

Consequently, a small part of the wet meadows/open areas is flooded and the reed-belts are fixated within a narrow height-range. Large multi-annual water level fluctuations combined with traditional land-use of the lake margins (that followed lake level movements) led to the removal of nutrients and renewal of reed, while limiting the width of the reedbelt. This likely led to less dense, younger and more species-diverse reedbeds compared to the present situation.

# Conclusions (2/2)

**Management Recommendations**

Vegetation management should aims for presence of wet meadows and open shallows in the altitudinal range 849-851m (covering all projected future water levels).

Fire-risk management should be integrated; open shallow areas and wet meadows double as fire-breaks.

Sluice management should explore larger multi-annual water fluctuations (848.50 - 850.60 m with rotational clearance at seasonal lowstands).

**Benefits**: shallow areas become available under all projected lake levels, nutrients / biomass around the lake are reduced, the potential spread of reedbed fires is diminished and the reedbed species-

# THE END

Thank you for you attention!