筑波大学 University of Tsukuba

地域水文気候研究室

気候変動時代の「水・エネルギー・防災」を AI×物理で支える

【課題】なぜ必要か

- ◆ 豪雨・猛暑・渇水など、極端現象が増大
- ◆ 太陽光・風力は気象に左右され、不確実性が大きい
- ◆ 「過去の気候」に基づく計画では将来リスクを捉えきれない
- ▶ 地域スケールで使える気候情報（高解像度・高信頼）が必要

【手法】どう解くか

- ◆ CMIP6・再解析・衛星・地上観測を統合（品質管理・欠測補完）
- ◆ 力学／統計／AIでダウンスケーリング（地域に合わせて高解像度化）
- ◆ 物理制約型深層学習で整合性を保持（放射・雲・風など）
- ◆ 1–10 km格子の将来気候データを構築（意思決定に資する形へ）

【成果】何が得られるか

- ◆ 極端気象リスク（洪水・猛暑・渇水）を地図化・指標化
- ◆ 再生可能エネルギーポテンシャル（太陽光・風力）の将来変化を定量化
- ◆ 自治体・企業のGX／レジリエンス計画の根拠データを提供
- ◆ CORDEX等の国際枠組みと連携し、アジア・アフリカへ展開

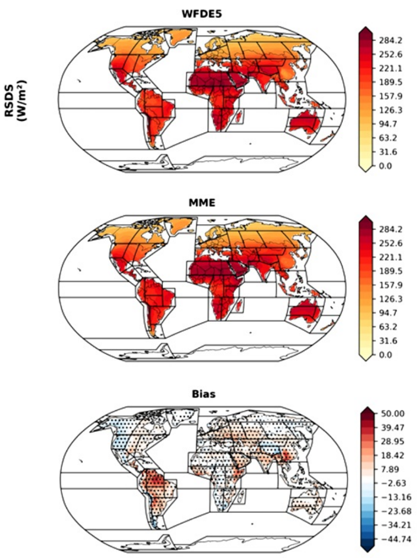
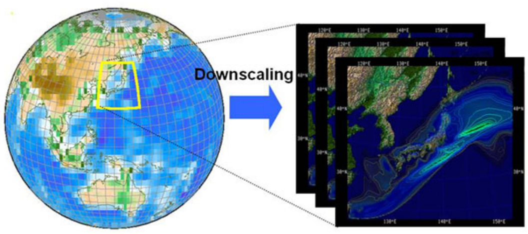


図1　日射量（RSDS）の全球分布とモデル誤差（基準との差）
上：基準（WFDE5：観測・再解析）
中：推定（MME：気候モデル平均）
下：差（Bias＝MME－WFDE5）



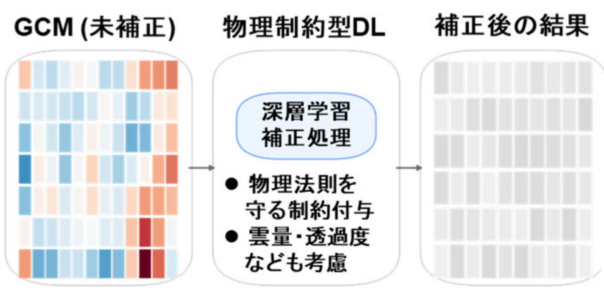
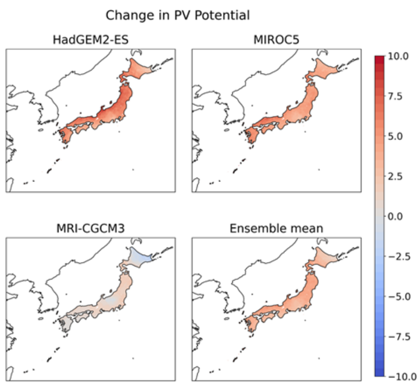


図2（上）　力学・統計・AIを組み合わせたダウンスケーリング手法
図2（下）　深層学習による降水・放射・風の高解像度化（ダウンスケーリング）



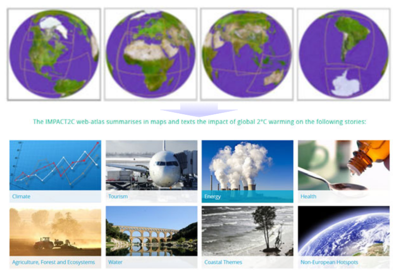


図3（上）　太陽光発電ポテンシャルの将来変化（気候変動に伴う日射量・気温等の変化を反映）
図3（下）　国際連携（CORDEX等）による手法・データの標準化と地域展開
（WCRP CORDEX をもとに作成）

研究室環境・進学情報

- ・メンバー：多国籍（アジア・アフリカを中心に約10か国）
- ・研究室ゼミ：週1回（大学院：英語）
  ※研究発表・議論を通じて、分析・モデリング・論理構成・プレゼン力を鍛える
- ・研究分野：気候学・水文学・AI・再生可能エネルギー（気候データ解析／ダウンスケーリング等）

歓迎する学生

- ・社会課題（気候変動・防災・エネルギー）に関心がある
- ・データ解析・モデリングに挑戦したい（未経験可）

主な進路

- ・エネルギー・インフラ関連企業
- ・官公庁・研究機関／大学院博士課程

メッセージ

気候が変わりつつある時代に、地域の水と大気のふるまいを理解することは、
社会の未来を考えることにつながります。
私たちの研究室では、そのための科学的知見を積み重ねる仲間を求めています。
興味をお持ちの方は、ぜひ一度お話ししましょう。

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IMAGINE THE FUTURE.

Regional Hydroclimate Laboratory

University of Tsukuba 筑波大学

Delivering Decision-Ready Regional Climate Information

AI-integrated, physically consistent hydroclimate science
for energy systems and disaster resilience

Why It Matters — The Research Challenge

Climate change directly shapes regional hazards and energy security, demanding scientifically sound and locally relevant climate information.

- Extreme events such as heavy rainfall, heat waves, and droughts are intensifying under climate change
- Renewable energy systems (solar and wind) are highly sensitive to weather and climate variability, leading to significant uncertainty
- Planning based solely on past climate conditions can no longer capture future risks

▶ High-resolution, reliable, and region-specific climate information is essential for effective adaptation and mitigation strategies

Approach — How Do We Address the Problem?

By integrating AI with physical constraints, we ensure scientific consistency while enhancing regional relevance.

- Integration of CMIP6 climate model outputs, reanalysis data, satellite observations, and in-situ measurements(including quality control and gap filling)
- Development of **physically consistent regional climate information** using dynamical, statistical, and AI-based downscaling
- **Physics-constrained deep learning** to preserve energy and water balances (e.g., radiation, clouds, wind fields)
- Construction of **1–10 km future climate datasets** translated into formats suitable for policy and engineering decision-making

Outcomes — What Can We Deliver?

These climate solutions provide decision-ready evidence for regional energy planning and disaster risk reduction.

- **High-resolution (1–10 km) regional climate projections** for energy systems and disaster risk assessment
- **Quantitative assessment of extreme climate hazards**, including floods, heat stress, and droughts
- **Climate-driven changes in renewable energy potential**, particularly solar and wind power
- **Decision-ready scientific evidence** to support national GX (Green Transformation) and local resilience planning
- **Contributions to international initiatives**, such as CORDEX, across Asia and Africa

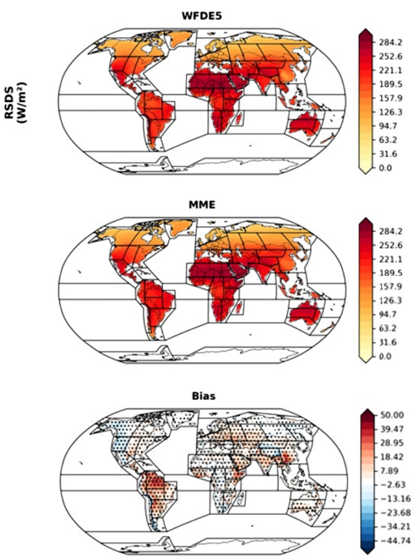

Figure 1: Global distribution of surface downwelling shortwave radiation (RSDS) and model bias, illustrating the need for bias-aware regional downscaling
Top: Reference (WFDE5: observation-based reanalysis)
Middle: Estimate (MME: multi-model ensemble)
Bottom: Bias (MME − WFDE5)

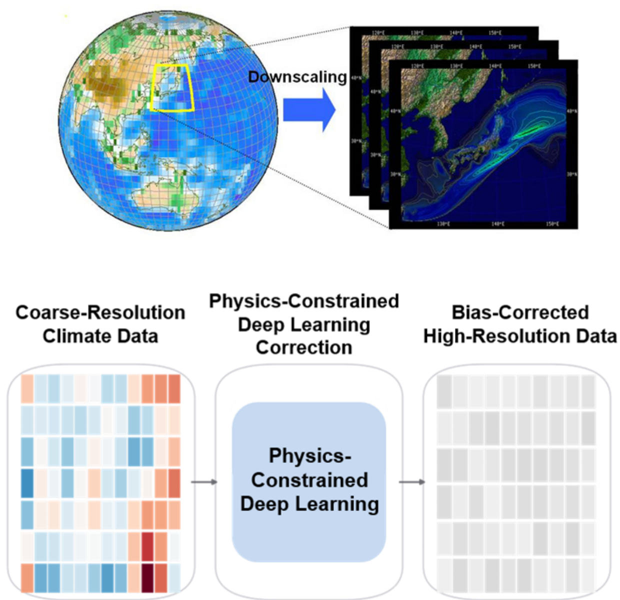

Figure 2 (Top): AI-integrated, physically consistent downscaling framework combining dynamical, statistical, and AI-based approaches
Figure 2 (Bottom): High-resolution downscaling of precipitation, radiation, and wind using deep learning

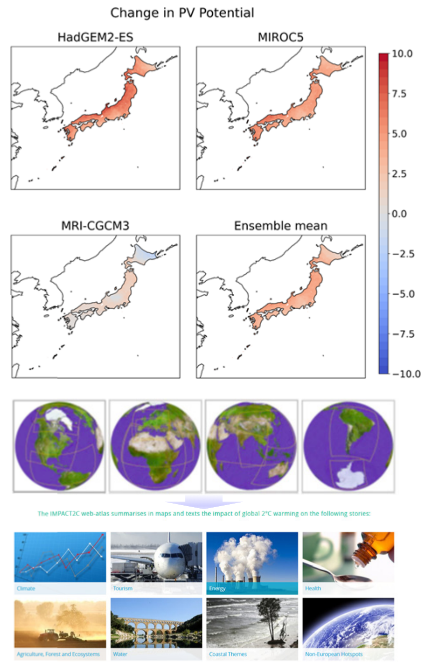

Figure 3 (Top): Projected future changes in solar power potential(reflecting climate-driven changes in radiation and temperature)
Figure 3 (Bottom): International collaboration (e.g., CORDEX) for methodological and data standardization and regional deployment
(Source: Adapted from WCRP CORDEX)

Research Environment & Graduate Study Information

- **Laboratory members** - A highly international group, representing approximately ten countries, primarily from Asia and Africa
- **Seminar** - Held weekly (graduate-level seminars are conducted in English)
  Students develop:
  - Data analysis and modeling skills
  - Logical scientific reasoning
  - Academic presentation and communication abilities
- **Research fields** - Climate science, hydrology, AI, renewable energy (climate data analysis, downscaling, etc.)

Students We Welcome

- Students with a strong interest in addressing **societal challenges**, such as climate change, disaster risk reduction, and the energy transition
- Students who are motivated to learn **data analysis and modeling**
  (Prior experience is *not* required.)

Career Paths of Graduates - Energy and infrastructure-related industries, government agencies, research institutes, and Ph.D. programs at universities

Message

In an era of rapid climate change, understanding regional water and atmospheric processes is essential to shaping a sustainable, resilient society.
Our laboratory welcomes highly motivated students and researchers who aspire to contribute to society through rigorous scientific reasoning and quantitative analysis. We would be delighted to discuss your interests and future goals.

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